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THE ONYX MARBLES OF MEXICO.

In the Mexican department of the International Exhibition at Philadelphia, are to be seen some fine examples of this beautiful stone, the introduction of which for ornamental purposes is rapidly progressing. The following interesting account of its origin, nature, and merits we take from the *Journal of the Society of Arts*, having been read before the Society by Mr. W. Eassie.

The Mexican onyx is a material of stalagmitic origin, formed by running water holding carbonate of lime, etc., in solution.

Stalagmitic formations of carbonate of lime, such as this is, may be deposited either in the floors of caves, in depressions of valleys, upon rock precipices, or in river-beds. But, as may be imagined, nothing but a careful examination of the deposits *in situ* will enable a geologist to say with certainty what manner of birth a certain piece of stalagmitic marble may have had. In our own country it occurs in every way upon a small scale. The well-known Gibraltar stone is another form of this stalagmitic carbonate of lime. The same may be said of the onyx from Algeria, which now alone, in point of extensiveness of deposit, can range with Mexico. I pronounce the Mexican product in every way superior to the Algerian one. I believe that nothing which has come down to us in the shape of marbles, formed in a similar manner, can in any one way compare favorably with a single specimen of the Mexican marble here present, either in beauty, solidity, or weight.

Having described this material as a stalagmitic deposit, I have nearly said all that can be said concerning it. I have not been able to obtain much information from the place where it occurs, further than that the quarry lies on the side of a hill, in a hilly district, chiefly of limestone formation, and that the beds seem to be both resting upon and covered by earthy deposits. A petrifying stream also runs at the foot of the quarry, and minerals are said to abound in the neighborhood. But I have not been able to learn whether the water is cold or sensibly hot, or whether it is colorless or tinted.

A most careful analysis, made in the metallurgical laboratory of the Royal School of Mines, of London, by Mr. W. J. Ward, is as follows:

"The three specimens of Mexican onyx marble received from you have been examined according to your instructions, for the purpose of ascertaining the nature of the coloring matters contained in them. The following constituents were detected by a qualitative analysis: Carbonate of lime, carbonate of magnesia, carbonate of protoxide of iron, hydrated peroxide of iron, oxide of manganese, sulphuric acid, water and silica.

"Copper, nickel, chromium, and cinnabar were specially tested for (as some of these were reported to be present), but none were found.

"The principal constituent, after the carbonate of lime, is the carbonate of protoxide of iron, both in the green-tinted and in the white marble. The various shades of red and yellow are due to the hydrated peroxide of iron. The proportion of manganese is very small, also that of sulphuric acid and of silica. The amount of iron present in the green-tinted marble is equal to 9.05 per cent of carbonate of protoxide of iron. The peroxide of iron in the red and yellow marble is 10.20 per cent."

The quarry from which come the samples before us is situated at Técali, about 35 English miles from the city of Mexico. The quarry is the only one in the country which yields a material so beautiful as regards color, or so valuable as regards the size of the blocks which can be exported.

In Mexico the custom is to insert and drive into the beds large wedges, made of a peculiar hard wood, which is known to grow in the immediate neighborhood of the deposits. The size of the quarry may be roughly given at 350 yards in length, 250 yards in width, and 27 yards in depth, which would give a total of over 63 millions of cubic feet of the material in that one deposit.

There is hardly a limit to the size of the pieces which can be raised; and if a means were extant of conveying these huge blocks to the coast, obelisks of the hugest size, and sarcophagi, finer than those of Egypt, and more magnificent even than the luxullianite one which contains the body of Wellington, might be introduced among us. The largest monolith I ever saw lay at the foot of a quarry in the Lebanon, measured 63 feet long, 15 feet high, and 10 feet wide, and must have been quarried in some such way as is now practised at Técali, inasmuch as blasting was unknown. I saw, also, upon the terrace of the great temple of Baalbec, three other stones over 60 feet in length, and I have no doubt similar shafts could be produced from Mexico. Should we ever desire to monumentalize a great hero of the future, as the Emperor Diocletian was by a single piece of stone at Alexandria, here would be a material that would put Pompey's pillar, and even Cleopatra's needle, in every way far into the shade.

The largest block of this material hitherto shipped from Mexico to Europe, measured 10 feet in length, 5 feet in width, and 4 feet in depth. The blocks are all conveyed from the Técali quarries to Mexico upon wooden carts, resembling arabas, and are then despatched by rail to Vera Cruz for shipment.

When blocks of this marble, to be used in slabs, are brought to the works, for instance, in Paris or London, they are sawn up by horizontal or other sawing machinery, in which the weight of the saw-frame and connecting-rod acts as a weight to press the saws down to their work. A 40-horse-power engine will suffice to compass the cutting of a block into thirty slabs at one time, the progress of sawing in such a case being three eighths of an inch per hour. Machine-ripping beds can, of course, be made as applicable for this hard material as for the various marbles; so can the revolving cylindrical cutters for bringing into form circular slabs, as table-tops. The polishing is performed much in the manner as with other marbles, the rectilinear works in a polishing bed, and the circular works in a lathe. This work of polishing is also performed in much less time than when marbles are in question, thus compensating for the apparently excessive time taken up in the sawing. When in the lathe it can be polished with the greatest ease, and the excellence of the polish is equal to any thing that can be desired. The superiority of this material over alabaster is here again manifest; for, whilst alabaster is polished by dried grass, and receives its satin-like lustre from the frictional action of soap-water, lime, and elutriated talc, such materials would have no effect upon the onyx marble. And another advantage is that it is not liable to show grease-contaminations, or be affected by them. Most marbles are also very susceptible to the stains communicated in an ordinary way by metallic solutions, spirituous tinctures of dyeing plants, and mineral oils; but the bulk of the Técali marble would remain unsoiled by them. I do not know of any material capable of taking a higher polish, or a more lasting one. Neither is the substance a brittle one, or apt to easily fracture, as might be supposed. No veined chalcedony or agate can exhibit a finer surface, or a better aris, even after the conversion of those gems into onyx proper, or the precious gem, for the purpose of the lapidary. This can be seen by an examination of many specimens before you. Moreover, it is equal in color, according to the portion of the slab from which the sample is taken, to any of the natural agates. I say *natural* agates, because the chalcedonies, cornelians, and agates were operated upon by the ancient engravers of gems in many ways, but chiefly by heating and steeping, in order to artificially heighten or alter the colors, and also to harden them by filling up the natural pores. There are no distinguishable pores to be seen in this peculiar onychinal material, as may be almost guessed when I state that a cubic metre weighs over 8000 lbs. Here is a cube, which, were it in stone, a man might easily poise upon his one hand; and I can, I think, defy him to even lift it with the aid of two hands. It is indeed a connecting link, as Mr. La Mert (who introduced it to this country) truly observes, between the precious stones and the marbles. Portions of it closely resemble that silicate of lime and magnesia which is known as jade, and which is about the hardest of all the minerals known. I exhibit to you a nephrite-like cameo of this pseudo-onyx, which will bear out these few remarks; and there can be no question that, for cameos and intaglios, the material before us will be largely patronized. The collection of cameos now before me can hardly be matched for beauty out of the most precious substance known to the arts.

Before I forget, I may as well, perhaps, here mention the cost of this material in the market. I am informed, then, that a cubic metre of picked material sells at about $525, or a cubic foot about $17.50. The price of slabs cut and polished, 1 inch thick, is $3.50 per superficial foot.

The strength of this material is very great, a ½-inch cube crushing only with a weight of over half a ton. It does not require, indeed, to be doubted, as would, for instance, the resistance to crushing of the serpentines and other building substances, which have been discarded owing to their liability to fracture from pressure of any kind. Frost, too, which sadly interferes with the suitability of many kinds of building materials, has, I understand, no effect whatsoever upon this onychine; and I know that it will also withstand the action of a considerable amount of heat.

No man of sense would attempt to decry the great value of our, happily, numerous species of marble, the bare enumeration of which, and a descant upon their many beauties, would take up a whole evening. Neither would he wisely seek to detract from the recognized value of our varied granites. He would not dare, either, to cry down the beautiful porphyritic granites of Shapfell, the pretty syenites of which we can fortunately boast, or the magnificent porphyries proper that comprise many of our rocks. He would only be laughed at for his pains if he did, and he would well deserve it. Enthusiastic as I am afraid I may have appeared in the matter of this substance, I would, after all, only claim for it a place on the dais of honor, where are ranged in glorious show the valuable materials which I have enumerated, feeling positive that it will meet with the attention which it deserves. It will be certain to do this, for there is scarcely a color or a tint missing, from the cream and white of the statuary marble and building elvans, down to the red of the Peterhead granites. The genius of color seems to have run riot when the foundation of these beds were laid, and to have proved its sobriety only upon rare occasions. I am given to understand that the deeper the quarries are worked, the greater are the surprises which are opened up in the way of color combination. I can not say that I should feel absolutely enamoured of a very extensive series of even such beautiful panels as some of these slabs would make for a hall or a corridor, and I would, perhaps, prefer the quieter shades. If I desired uniformity of appearance in a moderate way, I know that I could get it here, as the deposits are able to produce continuous series of any style. Color I certainly could obtain, color too, without the many harsh changes of the porphyry, and decidedly without the monotony of the granite. The finest color-imbued pillars in London are perhaps those in the British Museum Library, the Fishmongers'-hall, and the Carlton Club. But I wonder what would be the verdict of a jury of good judges of decoration, were these columns collectively compared with full-sized, and even unpicked polished shafts from Mexico.

The application of this substance to the fine arts has not hitherto been very extended, owing to its recent introduction to Europe. Amongst the minor articles into which it has been manufactured, however, may be mentioned bowls, vases, stands of all kinds, handles of doors, etc., lamps, and toilet ornaments.

It is not necessary for me to enumerate what function in architecture such a material as this might well perform, for its name would be legion. Floorings, wall-casings (bedrooms and living-rooms excepted, for sanitary reasons), columns, pilasters, plinths, dados, consoles, carvings, and mosaics, all are possible. It would be unwise to overcrowd a building with any one material, of course, for if we could imagine a beautiful Gothic church, such as that of Mr. Gambier Parry, at Highnam, near Gloucester, with the clustered columns, arches, and all the rest, chiselled out of the choicest marbles exhibited here, the effect would be too overpowering, even did the purse allow of such a lavish expenditure. There is one thing for which thin slices of this material, such as I now hold up, are excellently well suited, and that is, for the panes of windows, where the entrance of unchastened light would be offensive. Some of the oldest panes in the Mexican Cathedral, for instance, are made of thin plates of this very substance, and I have no doubt that the light admitted has an admirable effect. The lower windows of the Cathedral at Orvieto, in Italy, are also filled with panes of diaphanous alabaster. And, if ever cremation becomes common amongst us, what substance could be more beautiful than this for the reception of the ashes? Nothing could possibly make a finer cinerary vessel than, for instance, the one I now exhibit to you.

The paper was illustrated by a large collection of specimens of "onyx marble," lent by Mr. B. La Mert. These included slabs, pillars, vases, and a great number of small ornamental articles, *étagères*, clock-cases, tazzas, door-handles, trays, boxes, cameos, etc.

THE LENGTH OF PASSENGER-CARS.

A STANDARD-GAUGE passenger-car of average dimensions, and weighing 38,000 pounds, will seat 54 passengers, the proportion of dead weight to each passenger being 703 pounds. A narrow-gauge passenger-car of average dimensions, say 35 feet long, 7 wide, and weighing 15,000 pounds, will seat 36 passengers, the dead weight per passenger being 416 pounds, or 287 pounds per head less than that of the standard-gauge car. Now if there is no material error in this estimate—and we are persuaded that it is substantially correct—it shows very conclusively that unless the weight of the last named car can be lessened in proportion to the number of passengers carried, a decided advantage on the score of economy must be conceded to the narrow-gauge, so far as passenger-cars are concerned. It may be argued that the platforms, water-closets, stoves, etc., must be of the same weight for a short car as for a long one, and that the longer the car and the more passengers there are, the more this weight is divided up. There are other considerations, however, to be taken into account. If the length of a car-body increased, the framing must be strengthened in proportion, which is not yet perhaps very accurately known. The weight of a bridge between supports is approximately about as the square of the span, a 20-foot span requiring to be only a quarter as heavy as a 40-foot one. A long car-body has a duty to perform somewhat similar to that performed by a bridge, and it seems probable that its weight must necessarily be increased in a similar proportion. If so, it is obvious that, in the process of lengthening, a point must soon be reached at which the increase of weight from this cause will more than offset the advantages above referred to in the matter of platforms, etc.

Viewed in this light, it is manifest that there *is* a length more economical than any other. To determine what this length is would not be difficult if we knew the weight of the platforms, closets, and stoves, and also the rate of increase of weight due to lengthening the car-body. When these shall be definitely ascertained and the length of the car made to conform to such conditions, it will be found, we think, that the average length of standard-gauge passenger-cars, as they are now built, exceeds the limit of economy, by necessitating a larger proportion of dead weight to a passenger than is the case with the shorter narrow-gauge cars. The subject is well worthy of investigation and presents an inviting field of inquiry for car-builders.

A NEW USE FOR COLORED GLASS.

At a recent meeting of the Brussels Entomological Society, M. Capronnier called attention to the efficacy of certain colored glass in preventing the fading of the bright hues of preserved insects in collections. It is well known that the brilliant green and carmine hues of bodies of the *lepidoptera* are soon destroyed, and M. Capronnier undertook investigations to determine whether this was due to the action of pure sunlight. He accordingly placed portions of bodies under screens respectively of blue, green, violet, yellow, and clear glass, and exposed them to bright daylight, though not in the sun, for periods of 15, 30, and 90 days. With the clear and the blue glasses the color was attracted at the end of 15 days, and at the end of 90 days the normal red tint had become yellow. Green and violet glasses retarded the results about 15 days. With yellow glass, however, the color at the end of 90 days was scarcely attacked.

M. Capronnier concludes that yellow glass should be used for the show-cases in which entomological specimens are kept, and that the same should be employed for the panes in the windows of the room where the cases are located.

Fig. 1.

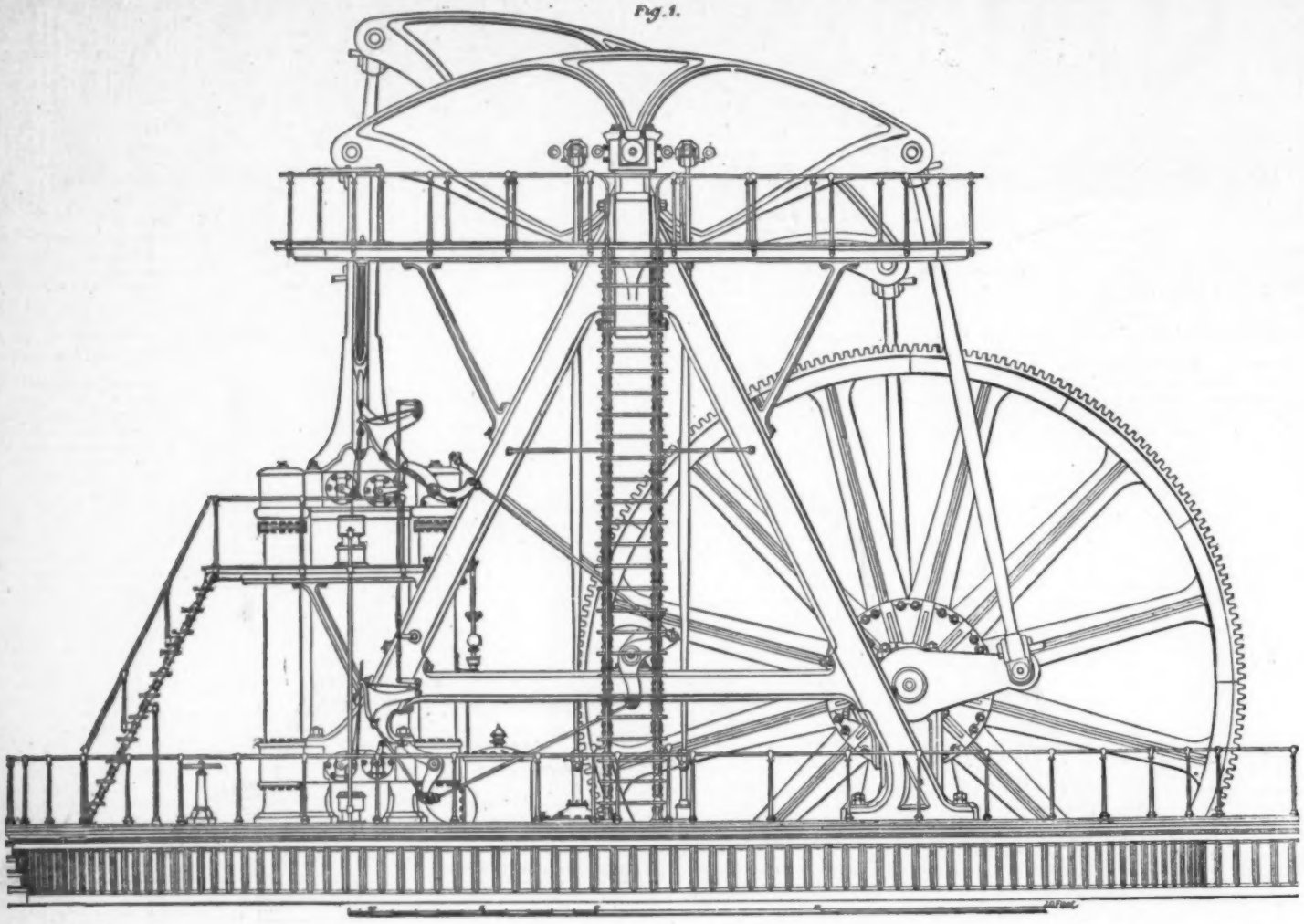
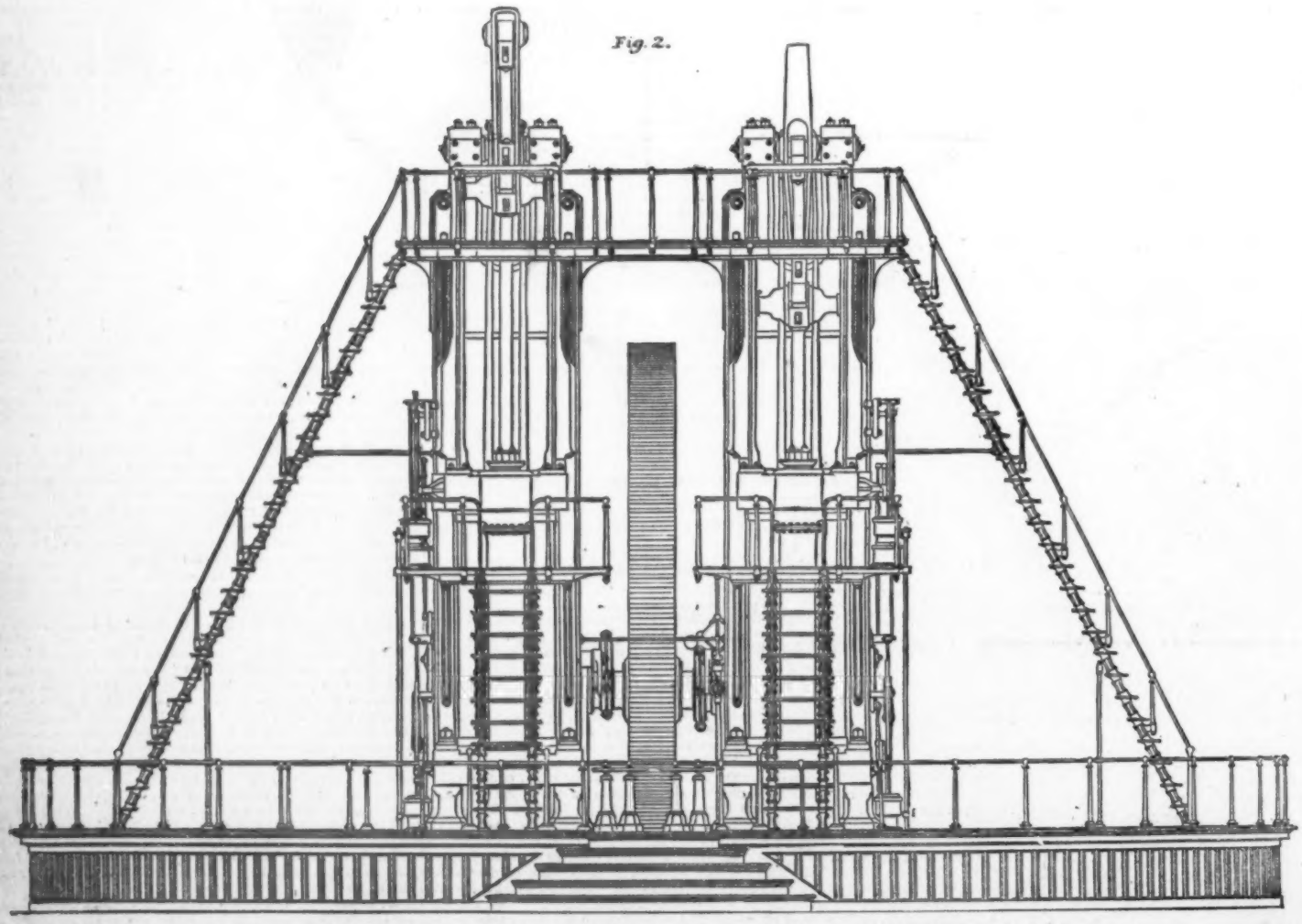


Fig. 2.



THE INTERNATIONAL EXHIBITION OF 1876.—THE CORLISS ENGINES.

THE CORLISS ENGINES AT THE EXHIBITION.

WE give this week elevations and plan of the magnificent pair of Corliss beam engines, constructed by Mr. George H. Corliss, of Providence, R. I., for driving the machinery at the Philadelphia Exhibition.

The pair of engines we illustrate are collectively rated at 1400 horse-power nominal, but they are capable of indicating 2500 horse-power. The principal dimensions are as follows:

	ft.	in.
Diameter of cylinders	3	4
Stroke	10	0
Diameter of piston-rods (steel)	0	6¼
Speed, 36 revolutions per minute, corresponding to a piston speed of 720 ft. per minute.		
Length of beams	27	0
Depth " " at centres	9	0
Weight of each beam, 11 tons.		
Length of fly-wheel shaft	12	0
Diameter " "	1	7
" " " at bearings	1	6
Length " " bearings	2	3
Diameter of fly-wheel	30	0
Width " " across the face	2	0
Number of teeth on fly-wheel, 216.		
Weight of fly-wheel, 56 tons.		

Each piston-rod carries a crosshead which works on fixed guides and is connected to its corresponding beam by a link, there being no parallel motion. The crosshead-guides extend from the cylinder cover to the top gallery, and by the side of each guide is a screw, by means of which the top cylinder cover with the valve boxes can be readily lifted so as to give access to the piston. This is a very convenient arrangement, and, so far as we are aware, a novel one.

As will be seen from the side elevation of the engines, the form of the beams is somewhat peculiar, it being quite a departure from the approximate parabolic contour usually adopted. The form is one, however, which looks well fitted for its work, and it is not likely to have been adopted by Mr. Corliss without ample reason. Each beam is cast in one piece. The bearings for the main centres of each beam are carried by a pair of **A**-frames, which also support the top gallery. The legs of the **A**-frames are spread so that one forms a straight connection between the base of the cylinder and the main centre, and the other between that centre and the plummer-block for the flywheel shaft, and the strains are thus directly transmitted and do not pass through a bed-plate, as is very commonly the case with beam engines. Access is given to the top gallery of each engine by a staircase at the side, and the two galleries are, moreover, connected by a central gangway, as shown in the plan.

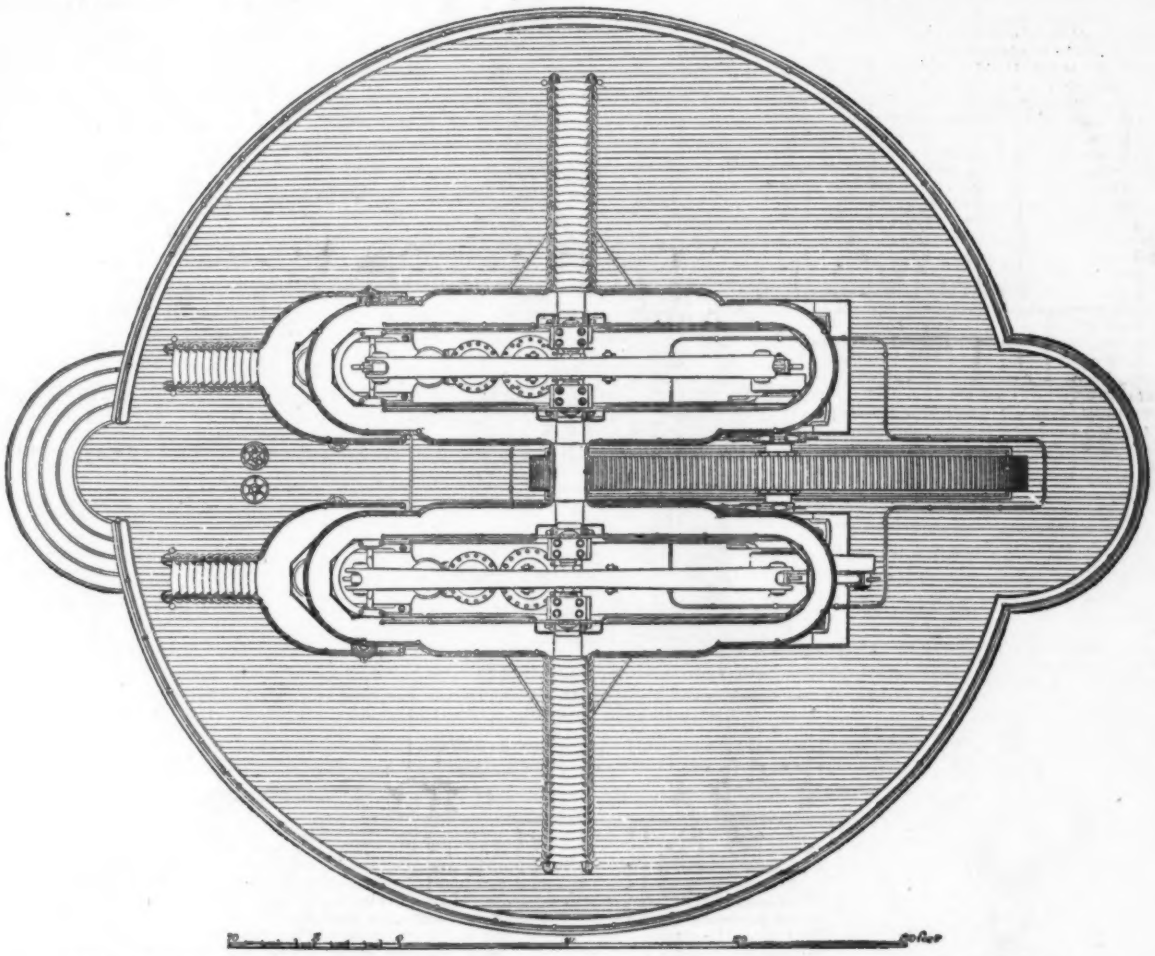
The general arrangement of the valve-gear will be best understood by an inspection of the side and end elevation; of the details of the gear we hope to give full particulars at a future date. The connecting-rods, which are about 24 ft. long, are of horseshoe scrap-iron, 9600 horseshoes having been used in making them. The cranks are of gun-metal and weigh 3 tons each. The flywheel is cast in segments, and its teeth are carefully cut, it being, it is believed, the heaviest cut wheel yet made. It gears into a spur-wheel 10 ft. in diameter and weighing 17,000 lbs., this wheel being cast in one piece. According to the accounts we have received, this gearing runs splendidly, and is almost noiseless. The 10 ft. spur-wheel is fixed on the main shaft, 252 ft. long, which runs across the building, this shaft driving at four points lines of longitudinal shafting by means of nests of bevel-wheels 6 ft. in diameter. All the shafting so far mentioned is beneath the floor line, the longitudinal shafts being each 108 ft. long, and extending to points directly beneath the ends of the lines of overhead shafting. At the ends of these four underground longitudinal shafts are the eight main pulleys, seven of these being 8 ft. and the other 9 ft. in diameter, all of them being 32 in. wide on the face. From each pulley a 30 in. double belt extends to the corresponding overhead shaft, there thus being a total width of 20 ft. of double belting to carry off the power of the engine. Each 30 in. belt drives a straight line of shafting 635 ft. long, and the belts run in glass compartments, so that they are visible, and form exhibits. Besides the underground shafting already mentioned, there is an extension of the main transverse shaft for a distance of 100 ft. to transmit power to the annexe.

The engine is erected with a platform 55 ft. in diameter, raised 3 ft. 6 in. above the floor of the building, access to this platform and to the engine galleries being given by staircases, as shown. Including the galleries, the total weight of the engine and its accessories is, 1,360,588 lbs., or rather more than 607 tons, and it required 60 10-ton cars to transport it to Philadelphia, the cost of its carriage from Providence, R. I., being $5443. We should add that work was only commenced on the engine on June 14th, 1875.

The engine, as it stands, undoubtedly forms a grand mechanical monument, and it is most fitting that such a prominent exhibit at Philadelphia should be associated with the name of Mr. George H. Corliss, an engineer whose designs have been so extensively adopted not only in his own country, but also in Europe. There is, in fact, no engine-builder whose patterns have been so universally imitated, and therefore none more worthy of the post of honor at an American exhibition.

The engine is supplied with steam by twenty upright Corliss boilers.—*Engineering.*

"ball" governors in the Hall, and a slow speed one at that, should so perfectly control this enormous machine. But to all who are familiar with the elegant tripping gear of Mr. Corliss, and understand how little resistance it offers to the variations of the governor, it is plain enough why he did not supply them with a more ponderous regulator. With the usual certainty of Mr. Corliss' devices, the use of the belt in connection with the regulator could not be admissible; it is therefore driven by toothed gearing direct from the shaft. As a consequence of these well-devised and carefully considered arrangements, therefore, it is impossible to detect, at any time after they have been put up to speed, the slightest variation in the number of revolutions. They run, too, as smoothly and noiselessly as a watch, so far as the engines alone are concerned, and nothing can be heard but the slight swish of the dashpots as the steam valves are tripped. The large gear-wheel and the pinion, as well as the bevels under the floor, can of course be heard, but not at all disagreeably; and now that the other machinery is pretty nearly all in motion, one has to get quite close to them to detect the low rumble which proceeds from them. It seems entirely to be regretted that the masterly piece of work embodied in the subterranean shafting and the wheels which give it direction should be hidden from view; and I think that the outlay would be well invested, and several interesting objects be added to the Exhibition, if, at least, the four sets of bevel-wheels were exposed to view, as they might safely and easily be by placing strong glass panels in the present octagonal coverings. These bevels are specimens of workmanship such as are not to be seen or found in any other spot on the globe, and notwith-



THE INTERNATIONAL EXHIBITION OF 1876.—PLAN OF THE CORLISS ENGINES.

THE INTERNATIONAL EXHIBITION OF 1876.

THE CORLISS ENGINES.

No. II.

THESE magnificent machines, illustrated herewith, have now been in successful operation for several weeks, and have already demonstrated the ability of the men who have designed and constructed them, and the capacity of the establishment in which they were built, to produce a steam engine equal, if not superior, to any thing in this or any other country. As yet they have not been "indicated;" it would be difficult, therefore, to say, with any considerable degree of exactness, what power has been developed by them. To know, however, that they will be abundantly capable of meeting any demands likely to be made upon them, it will be sufficient to say that with 60 lbs. pressure it has not yet been found necessary to admit the steam to the cylinders during a fraction of the stroke exceeding ½; and, as there is little probability of any considerable addition being made to the power-absorbing machinery in the Hall, and, as 75 to 80 lbs. of steam may be carried if necessary, this will be about the grade of expansion used during the Exhibition.

Engineers will be anxious to know exactly what these elegant and advanced specimens of engineering are doing in the way of economy of fuel, and I hope to be able to give you reliable data in that direction as soon as they have been a sufficient time in operation to render it correctly obtainable.

The governing mechanism operates perfectly, and to the uninitiated it seems almost a marvel that one of the smallest of standing that the machine upon which they were cut, and which was specially designed for their production, is on exhibition near the engines (and of which I shall soon send you a full description), it would be far more satisfactory to see them in actual operation.

One of the most felicitous conceptions of Mr. Corliss, in connection with the valve-gear of these engines, is the manner in which he effects an exceedingly quick and wide opening of the exhaust valves, a desideratum which will be readily recognised by engineers. In the opening of this valve wide it is necessary to rotate it through quite a quadrant of the circle, and to do this while the engine makes but a small fraction of the return stroke was no simple problem; to the eye, however, the engine has scarcely turned the centre before the exhaust is opened to its full extent, and is closed as quickly when the proper period arrives. One of the most difficult problems which besets the steam engineer is that of reducing the time required for the opening and closing of the valves of a steam engine to a minimum; and certainly it was never more nearly or completely solved than in this device. The arm of a curved lever or bell-crank may be imagined as vibrating through a small arc, which, if drawn on paper as described by the extremity, would nearly touch the circle of which about ¼ is described by the extremity of the valve arm; these two extremities are connected by a very short link, of sufficient length only to admit of the valve arm being in a vertical position when the link becomes horizontally situated, or nearly so; the effect of this arrangement and relative position of parts is to give rapid motion to the valve arm, particularly during the first portion of its opening motion, while the long arm is moving comparatively slow. This little device, although the embodiment of simplicity, performs a function of the greatest importance in the economic working of the engine, and one which has been most diligently sought after by inventors, but until now with no very marked success. The peculiar features of the cut-off gear I will hereafter more fully describe when I can refer to the plans.

Another peculiarly happy idea is developed in the manner

in which the cylinders and steam pipes connecting the valve-chests are encased, although it is without doubt a most expensive one. Instead of the usual sheet-metal casing or wooden stave "lagging," filled in with non-conducting material, a series of cast-iron rings of considerably larger diameter than the cylinder or pipe is used, and these filled in with felt or other non-conductor. The rings are nicely turned and finished in the lathe, and cut into semi-cylindrical pieces with a very narrow parting tool. These semi-cylinders are dowelled together in such a way that the vertical joints of successive rings do not meet, but make what is technically known as "broke joints." With this method each piece may be removed separately by simply lifting them off successively, high enough to withdraw the dowel-pins; while they form an exceedingly strong and compact form of casing when together. Both the circular and vertical joints are bevelled for about $\frac{1}{4}$ of an inch, which with the high polish given them presents a novel and attractive appearance.

Nothing could be more felicitously conceived than the placing of the delicate and comparatively infinitesimal machinery of the Waltham watch-making establishment in immediate contrast with these massive productions. About a dozen women are busily engaged during the running hours in operating as many of the beautiful and delicate machines of this watch company, producing almost microscopic objects, such as screws and pivots, wheels and pinions, appertaining to the watch, and in the immediate vicinity of a machine which has iron enough in it to make all the parts of all the watches which could be produced by all the watch-makers in the world from now to the first millennial of our independence; and which, moreover, is powerful enough to drive all the watch-making machinery in the solar system, even if a proportionate number of time-keepers are made upon the other planets. There is something quite fascinating in this contrast, and the happy idea of placing these two exhibits in juxtaposition is much to be commended.

An excellent provision, and one which well illustrates the foresight of the Corliss Company, is the arrangement for examining the pistons, whenever necessary. On the outside of the frames containing the piston-rod guides may be seen two long screws, extending down to below the top cylinder head; these screws work in nuts contained in the top steam-chest, and have collars on their upper ends which reach upon the upper framing. When the cylinder head is to be removed, it is only necessary to remove the bolts which secure the steam-chest to the top of the cylinder, and by means of these screws raise the entire steam-chest, cylinder-cover, and guides at one operation, and without other preparation. When raised clear of the piston-rod, the whole of this work intact can be moved back upon the framing out of line with the cylinder, when the piston and rod may be raised out if necessary. With this arrangement, work which in this form of engine usually occupies days can be accomplished in a couple of hours. In fact, the more one sees of these machines and their working, the more he finds to commend and approve; and I hope to be able to send you soon some of the diagrams taken from them, as well as from the air-pumps, together with all the necessary data in determination of their economy, accompanied with plans and a more detailed description of the various parts; and I have no doubt but that it will be found that they are producing an indicated horse-power on a consumption of not more than about 15 to 18 lbs. of steam per hour, and possibly less. J. T. H.

THE INTERNATIONAL EXHIBITION OF 1876.

STEAM ENGINES.

No. 12.

MESSRS. HAMPSON, WHITEHILL & CO., both for themselves and the Ames Iron Works, make a very creditable display in the above line. They exhibit in Annexe No. 2 a horizontal

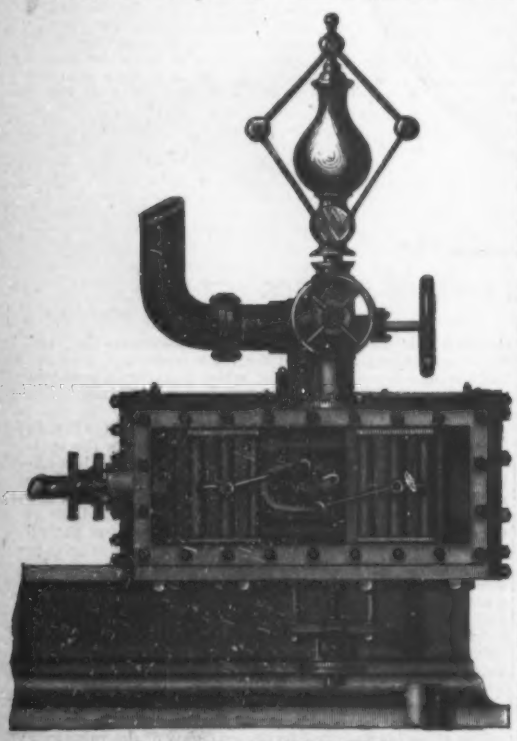


FIG. 1. INSIDE OF STEAM-CHEST.

engine, in use driving the line shaft, with 16 in. by 36 in. cylinder, having a new automatic slide-valve cut-off, the invention of Mr. E. Penny. This cut-off was on exhibition for the first time at the last fair of the American Institute in New-York, and is an ingenious, simple, and thoroughly practical device. An automatic slide-valve cut-off has long been a desideratum from the simplicity and many inherent excellencies in that form of valve; and among the numerous attempts in this direction, this piece of mechanism will occupy a prominent place.

The construction is fully shown in the Figs. 1, 2, and 3 and Fig. 4 is a copy of diagram from the engine cutting off at about $\frac{1}{10}$ from commencement of the stroke, under 55 pounds initial pressure in the cylinder.

In this device the main slide-valve is the same as the double-ended or "spectacle" valve with the ports passing through them instead of admitting steam to the cylinder ports past the outer ends. Upon this slides a second valve, having but one opening at each end on the under side, each of which branches into three openings on its upper face; these two valves are operated by separate eccentrics. Upon the upper face of the second or gridiron valve are placed two gridiron blocks, each of which has three openings through them corresponding to the openings in the upper face of the second valve; and these blocks have no other motion than what is imparted to them by the governor, which is to separate them or bring them closer together, and is accomplished as follows: Upon a stud in the steam-chest a double and equal ended lever is pivoted; this lever has an arm projecting at right angles to the other equal arms; to the latter the blocks are connected by links, and to the T arm is attached the governor rod. The effect of this arrangement is that by increased speed of the governor, the blocks are separated, and the steam thus cut off from passage through the second valve, and *vice versa*. To prevent sudden fluctuations or overrunning of the variations of the governor, a dash-pot is placed below the steam-chest, and the governor rod extended out through a stuffing-box to a piston working in it. The slight motion to be given to these blocks to compensate for a change of load requires very little force to

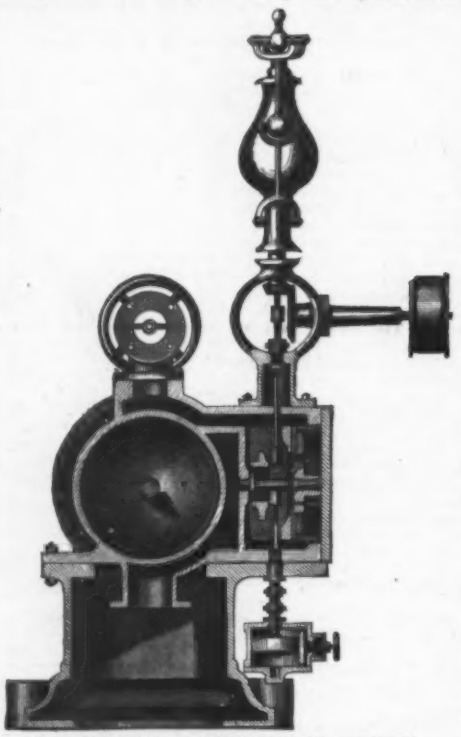


FIG. 2. VERTICAL CROSS-SECTION OF CYLINDER.

be exerted by the governor, while the friction of the second valve, as it is moved under the blocks by the eccentric, is rendered nil in its effect upon the governor by the blocks being connected to the double lever. It shows itself in practice to be sensitive, has all desirable range, and does not throttle or wire-draw the steam under any practicable grade of expansion.

This firm also exhibits a horizontal adjustable cut-off engine which is governed at the throttle: a fair specimen of workmanship, and a good, substantial machine. For the Ames Iron Works they exhibit several excellent semi-portable and portable engines. In all these the good feature is observed of having the bed or frame of the engine distinct from the boiler, with permanent footing-pieces bolted to the latter, as well as the equally commendable plan of making at once a feed-water heater and a much stronger girder of the bed casting by putting it into the box form. The high and various coloring, however, of this machinery must, wherever resorted to, be deprecated; although the fact that the painting of their machines a bright vermilion, with yellow striping, has for a long time been a kind of trade-mark with this firm will be some excuse for its retention; but there can be no excuse for the execrable taste displayed in bronzing and gilding the rivet-heads of boilers, as is done on the Ames portable engines. It has been told of a novice who entered a boiler-room in which the rivet-heads of the boilers had been painted red, that he turned to his companion with advice to get out again as quick as possible, as the rivets were getting red hot; and the expert would be as likely to turn from these gilded rivets for the better reason that this tawdry kind of ornamentation might be expected to cover up or compensate for some real defect.

Among the many specimens of the portable engine to be found on exhibition, it is a most anomalous fact that there is not one which is propelled over the ground by its own steam power; it is not less than a reproach to American engineering, to see so many of these, in other respects most excellent machines, accompanied with the inevitable tongue, whiffletrees, and other paraphernalia of equine traction. If there is a field in which the American engineer may hope to gather easy laurels, it is this; for certainly there is nothing in this day which savors more of "carrying coals to Newcastle" than to see a man perched upon a steam-boiler having upon it a steam-engine complete, driving a pair of horses in order to move it from place to place.

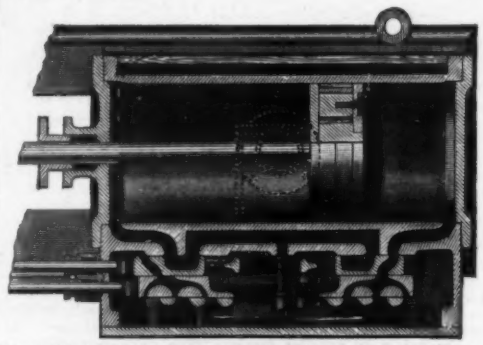


FIG. 3. HORIZONTAL LONGITUDINAL SECTION OF CYLINDER.

The road locomotive, so well represented in the British section, and which has done such good service in and about the Centennial buildings, either in the traction and portable engine form, or the road-roller, or as combined with the steam-crane, is nowhere to be seen among the American exhibits, and aside from the self-propelling steam fire-engines, this nation has but a solitary specimen of this application of the steam-engine; and as if in derision of even this one attempt, it has been christened and flamingly emblazoned with the name "America," in letters over a foot in height. If this is the best, however, that American engineers can do in that direction, it would have been better to have waited until the next Centennial before attempting competition in that line. For crudity of design, and inferiority of workmanship, it certainly eclipses any thing in, if not outside of, Machinery Hall.

There are, however, some features in the machine, and which, perhaps, it has been the design of the owner or builder to exhibit, which, if properly developed, will be found to be commendable ones. The periphery of the driving-wheels is made up of a series of rectangular cast-iron boxes with the openings outward. Into these are crowded cubes of india-rubber, which project about one inch beyond the casting, making what would appear to be a good traction device, and something resembling a large spur gear with rubber teeth of exaggerated pitch and small depth. The durability of this arrangement may be questioned.

Its general design is that of a vertical boiler, having a pair of horizontal cylinders attached to its sides, which give motion to a shaft lying horizontally in front of it. This shaft gears down to another below it, which carries on each of its ends a slip pinion operated by forked levers from above, to gear into large gears attached to the inside of the drivers. The leader is a single wheel of small diameter constructed in the same manner as the drivers, except that the rubber blocks are supplanted by chunks of cast-iron of the same dimensions, suggesting unmistakably that the rubber, in this place at least, has failed to withstand the wear and tear. This leader is operated to give direction to the machine by means of gearing and shafts from a handle placed convenient to the driver to a vertical shaft, bifurcated to receive the wheel. The engines are reversed by means of the ordinary link motion, in which, however, the very extraordinary expedient has been resorted to of placing two overhung cranks outside of and attached to the crank-pin and to each other, to take the place of eccentrics. This method of imparting motion to the valve is often used in place of a single eccentric, but has always been considered a rather insecure and unreliable arrangement; but to add a second crank outside of the first is about as unmechanical and unstable a contrivance as could well be devised. Add to this that the eccentric rods have to be curved and bent out of all semblance to that piece of mechanism as generally known; that the frame of the machine is of the crudest possible construction, and that the method of securing the various parts together is done much after the manner of the school-boy carpenter in constructing his first vehicle, and we have a make-up which, as a specimen of American engineering, would be a more appropriate exponent of the extreme southern point of the continent rather than of this latitude.

The Erie City Iron Works exhibit a portable engine having a vertical boiler, with a horizontal engine. The latter has a bed with something of the lathe-shears form, with one end attached to the boiler and the other arranged to receive the king-pin of the front axle. There is an exceedingly good distribution of parts in this machine, and one is very strongly tempted, upon examination of it, to conclude that this is altogether a better arrangement of boiler and engine for portable purposes than is possible with the horizontal boiler. A careful examination of the road-locomotive "America" will too, I think, tend to the same conclusion, notwithstanding that the idea is so miserably carried out.

This firm also exhibit a portable and a semi-portable engine with horizontal boiler, both of very good design and workmanship. Nowhere, perhaps, among this class of machinery is the absurdity of propelling it by means of horses more ap-

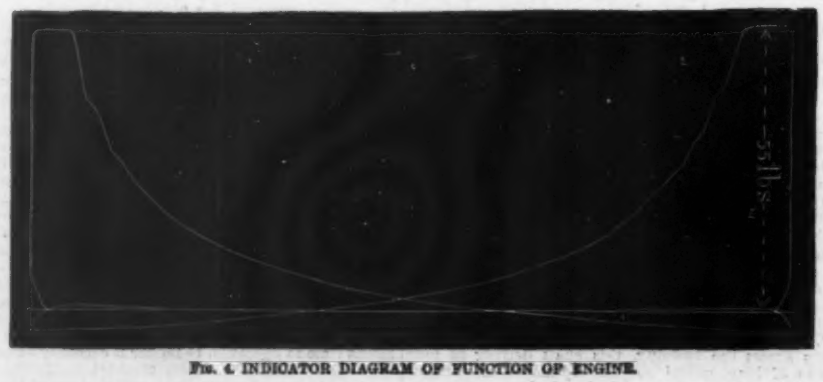


FIG. 4. INDICATOR DIAGRAM OF FUNCTION OF ENGINE.

parent than in the specimen with vertical boiler above mentioned. So small an addition, even to the machine as it now stands, would serve to make it self-propelling, that it is no less than astonishing that some arrangement of parts has not been devised for it with that view; but underneath it lies the inevitable horse-attachment, which has cost as much money to construct as would be required to add all that is necessary to the machine to make it self-propelling. It is to be hoped that some of our enterprising engineers will before long recognize the field here open to them, and leave the relic of fogyism (a horse dragging a steam-engine) to drop back into the past where it belongs.

The last-mentioned firm exhibit two sizes of horizontal stationary engine, the smaller a plain slide-valve throttling engine, and the larger having an adjustable slide-valve cut-off. In this concern is another commendable example of a little trouble taken to assist the visitor in a comprehension of the particular features of their machinery: the steam-chest cover of their cut-off engine is removed, exposing the interior mechanism of the cut-off to view. The steam-ports passing through the slide-valve proper stand in an inclined position such that they converge toward one side of the valve. A V shaped block having the same inclination to its sides as that of the ports in the valve, is actuated by a second eccentric, and this block is adjusted vertically or transversely of the steam-chest by means of wedge-shaped pieces under its edge, which are operated from without the steam-chest, arresting the flow of the steam to the cylinder sooner or later in the stroke, as may be desired. The workmanship on all these machines is excellent; but one very radical defect is observable in the design of the frame, which places the eccentrics in such a position as to necessitate an excessive offset in the eccentric-rods; and which is anything but mechanical or well advised.

Nelson W. Twiss, of New-Haven, Conn., exhibits several of his, now pretty well known, vertical engines. The use of the hollow column, enlarged below to clear the crank in its revolution, upon which the inverted cylinder is placed and cut away at the sides for access to the parts, and so much resorted to for the vertical engine, is well advised in this machine. Mr. Twiss's specialty is small-powered engines, and for lightness of parts combined with good proportion and workmanship, his machines—although making quite an unpretentious exhibit—are not excelled in the building. J. T. H.

THE COPPER TREE OF SPAIN AT THE EXHIBITION,

AND AN ACCOUNT OF THE OCCURRENCE OF COPPER IN VEGETABLE AND ANIMAL BODIES.

IN the cell fluids and also cellular or woody structures of plants are to be found certain and constant substances of mineral origin that have been derived from the earth by solution, and which constitute an exceedingly important part in the growth and nutrition of plant life. Should such minerals as the plant requires for the elaboration of its organized structure be withdrawn, by placing it in a soil perfectly free from them, the plant will soon perish and decay.

These substances, with the exception of a few volatile ones, as nitric or sulphuric acid, and phosphoric acid, as likewise metallic chlorides that may by burning be decomposed, are to be found in the ashes of the plants after calcination. The ashes or mineral constituents of plants differ among themselves materially, not alone as regards quality, but particularly as respects quality. The seeds in particular are rich in mineral ingredients, whereas the old, strong, woody organisms are comparatively poor. The average quantity of ash yielded by plants amounts to about five per cent in the green state, before being dried.

In the ashes of plants throughout are to be found the oxides of potassium, sodium, calcium, magnesium, iron, manganese, and the acids: carbonic, phosphoric, sulphuric, silicic, and chlorine; as also in sea plants iodine and traces of silver and copper. In a few cases, alumina and sulphur are present.

The present communication confines itself to the inorganic substances alone, and not to the organic constituents of plants. Should the soil contain certain metals that are set free by disintegration, they may be taken up by some forms of plants and stored up in small quantity in their woody fibre. Such is the case with a tree growing in Spain upon a copper-bearing soil, the ashes of which contain, it is said, as much as two per cent of copper as oxide. And what is more remarkable of this tree—pieces of which are to be seen in the mineral department of the Spanish section of the Exhibition—is that a cog-wheel is also exhibited, made wholly of copper from the veritable tree. In working up such a tree, every thing is utilized, as the wood may first be subjected to destructive distillation whereby pyroligneous acid is obtained from which acetic acid is extracted. The residue is charcoal in the retorts, which may be used as fuel for heating the retorts in the process of distillation. The ashes that then remain contain the copper, which can readily be extracted by smelting.

Thus it is seen that every part of the tree is made subservient to its own reduction; its own charcoal is used for distilling the wood, which yields more charcoal; the liquid products of distillation are valuable, and the resulting products of combustion and disintegration; the ashes are employed for the extraction of copper. All the forces that have been employed in constructing the elaborate tissues and storing up the different constituents, are again required to undo by analysis the preceding work of synthesis.

Such is the ever-recurring cycle of integration and disintegration, of combining and uncombining—it is the history of life.

Copper has been found in sea-weeds by Malaguiti, Durocher, and Sarzeau, which proves the existence of copper in small quantity in sea-water, from which the plants collect it by absorption. It has also been found in the blood of certain molluscs and marine animals. Copper in minute quantity has been found in the bodies of animals of high organization, even as a constant constituent of man. According to Odling and Dupré, copper in small quantity is of constant occurrence in flour, straw, hay, meat, eggs, cheese, wheat, liver, kidney, blood, and many other varieties of food. In the animal organism it exists in proportionately large quantity in the liver and the kidneys, whereas only traces occur in the blood.

Sarzeau, in the year 1858, made some remarkable calculations in respect to the annual amount of copper which the French nation consumed in the bread they ate. The population of France then equalled thirty millions, each individual eating about one pound and five ounces of bread daily, which equals, for the whole population, over thirty-nine million pounds of bread daily, which contains twenty-two pounds of copper. In one year, therefore, about three tons and a half of copper are consumed in the wheat as bread by the people of France alone.

The ashes of the oak contain, according to Dr. Forchhammer, some iron, manganese, copper, tin, lead, zinc, cobalt, and even traces of nickel, all in the form of oxides.

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FRENCH ACADEMY OF SCIENCES.

APRIL—MAY.

On Electric Fuses. By M. Ris.—The fuses employed for the electric inflammation of detonating mixtures may be disposed either for tension currents or for quantity currents. With the first the firing is produced by a spark generally resulting from induction apparatus; with the second, by the calorific action of energetic couples, of which the current is transmitted by a conductor of large section to a very fine platinum wire, which it heats to about 472° Fah. If it be attempted to fire an induction fuse by a battery current, a large number of elements is found necessary; and on the other hand, platinum wire-fuses can not be ignited by a tension current. The author suggests rendering induction fuses conductors, by incorporating with the detonating mixture (usually of chlorate of potash base) a small quantity of pulverized platinum sponge. Fuses are thus obtained, which are inflammable either by induction or battery currents.

On the Fauna and Flora of the Champagne Peat Beds. By M. Fliche.—The traces left by man are very numerous, and include charcoal in large hearths; pieces of wood partly carbonized; vases, some roughly made by hand-moulding, others actually turned; bones, some carved; silex, fragments both polished and rough; pieces of sandstone, and objects in bronze and iron. Finely polished and carved flints of the same epoch are found in the lower part of the beds, while mixed with them are other flints of coarser workmanship, giving new evidence of the care necessary in determining the chronological classification of these objects. The fauna is analogous to that of the time of the lacustrian habitations of Switzerland. The flora is more interesting, and from the vegetable remains it is possible to follow its variations from the loam, which forms the basis of the peat up to the present epoch. The flora of the north of France, very different at the quaternary epoch from what it is to-day, has gradually reached its present state through the increase of climatic temperature, which has caused the disappearance of certain species, and at the same time permitted others to exist and to dominate. The struggle for existence between species has thus caused great modifications in the areas relatively covered by them, and does not show that the present flora is derived from that which preceded it, as would follow according to transformist theories.

On a New Process for determining Astringent Matters. By M. F. Jean.—The author finds that the solutions of various astringent principles, when added to a carbonated alkali, absorb the solution of iodine with an energy comparable to that of arsenite of soda. Numerous trials have demonstrated that this absorption takes place exactly in direct ratio to the quantity of astringent matter experimented upon, and that one part by weight of dry tannic acid absorbs four parts of iodine to form a compound not yet studied. It is on this action of iodine on astringent matters that the process referred to is based.

On the Cyanide-cyanate of Chloral. By M. C. O. Cech.—On mixing equivalent parts, in extended solutions, of hydrate of chloral, cyanate of potash, and cyanide of potassium, a violent reaction is produced with abundant disengagement of hydrocyanic acid. There is thus obtained an oil, which soon solidifies and forms fine white, and often very long needles. These crystals are soluble in ether, alcohol, glacial acetic acid, sulphide of carbon, and water. They melt at 175° Fah. The body deposited is needles from the alcoholic solution by adding water, melts on the platinum plate with disengagement of hydrocyanic acid, and of isonitrile. Analysis gives it the formula $C^4\ H^3\ Cl^3\ N^3\ O^3$, which corresponds to a composite body of chloral, hydrocyanic, and cyanic acids, $C^2\ H\ Cl^3\ O + C\ N\ H + C\ N\ O\ H = C^4\ H^3\ Cl^3\ N^3\ O^3$.

New Process for obtaining Imprints of Plants. By M. Bertot.—The plant or portion thereof, of which an imprint is desired, is repeatedly pressed against oiled paper, and then folded in the same, the whole being enclosed in several sheets of common paper until required for use. In pressing the plant against the paper, the hand is rubbed over the upper side in every direction, a process which determines the adherence of a small quantity of oil to the other side of the leaves. The plant is then placed upon white paper, and carefully pressed thereon as before. It is then removed, and the paper covered with finely pulverized plumbago, which afterwards is dusted off. The image of the leaf will appear as the plumbago will adhere to the greasy marks left by the pressure, and not elsewhere. With an assortment of colors—pastels in powder for example—the natural hue of the plant may be reproduced. In order to fix the imprint to the black lead, or other colors, an equal portion of resin is previously added. Then, after imprinting, the paper is heated either before a fire, or with a hot iron sufficiently to melt the resin, which, on cooling, renders the print ineffaceable.

On Experimental Researches on the Pulmonary Respiration of large Domestic Mammifers. By M. A. Lauson.—Of the animals experimented upon, 52 in all, 22 were equine and 30 bovine. The experiments show that a few millimetres of decreased barometric pressure, and a few degrees of thermometric elevation, suffice nearly to double the elimination of carbonic acid in a unit of time.

On the 163d Asteroid.—M. Le Verrier announces the discovery of this latest member of the asteroid family, by M. Perrotin, at Toulouse, on April 26.

On Feldspath Mirocline, and on Andesine. By M. St. Claire-Deville.—Up to the present time orthose has been considered as characterized by the predominance of potash, albite by that of soda, and no connection has been recognized between the two minerals, which under two incompatible crystalline forms possess the same chemical formula, 1 : 3 : 12, in which the three numerical elements respectively represent the oxygen of the protoxide, the oxygen of the sesquioxide, and the oxygen of the silice. The conclusions of M. des Aviseaux have recently established this connection: Potassium becomes the pivotal body between the two minerals, and as amphigene (1 : 3 : 8) is also of a dominating potash base, it will be seen that potassium is the bond between the feldspathides and the amphigenides, the same as calcium is common to anorthite and to certain varieties of sarcolite, that is to say, to the minerals of formula 1 : 3 : 4, having different crystalline types.

On New Researches on Gallium. By M. Lecoq de Boisbaudran.—This discoverer has now reduced to a metallic state nearly 1.5 grains of gallium which is sensibly pure. It melts at about 85° Fah., so that it liquefies when held in the hand. When solid, the metal is hard and resistant even to a few degrees below the melting-point. It can be cut, and possesses a certain malleability. When melted it adheres easily to glass, on which it forms a beautiful mirror, whiter than that produced by mercury. When heated to a bright red in air, it does not oxidize but very superficially and does not become volatile. The density of the metal (approximately determined) is 4.7 at 59° Fah.

On a New Crystallized Organic Substance. By M. Loiseau.—Raffinose in a state of purity has a faint sugary odor. It may be obtained in the form of crystals more or less large, which, when very fine, are white, and increase in transparency with their size. Dried in air on bibulous paper, it is almost insoluble in alcohol at .9. It liquefies even completely without the intervention of water, when submitted in a hermetically sealed tube to a temperature of 145° Fah. Dissolved in water, it has a rotatory power above that of sugar. It contains carbon, 36.4; hydrogen, 7.07; oxygen, 56.63. Its formula is $C^6\ H^7\ O^7$, or one of its multiples. The composition of anhydrous raffinose thus differs very little from that of crystallized sugar.

PHYSICAL SOCIETY, LONDON.—APRIL, 1876.

Prof. GLADSTONE, F.R.S., Vice-President, in the Chair.

IMPROVED HELIOSTAT.

The Secretary read a communication from Sir John Conroy, Bart., "*On a Simple Form of Heliostat.*" The defect of Fahrenheit's heliostat, in which the beam of sun light is reflected by a mirror moved by clockwork in a direction parallel to the axis of the earth, and then in the required direction by a fixed mirror, consists in the great loss of light. The author substitutes two silvered mirrors for the looking-glasses usually employed, and he has shown that the loss of light with this arrangement is less than when the light is once reflected from a looking-glass.

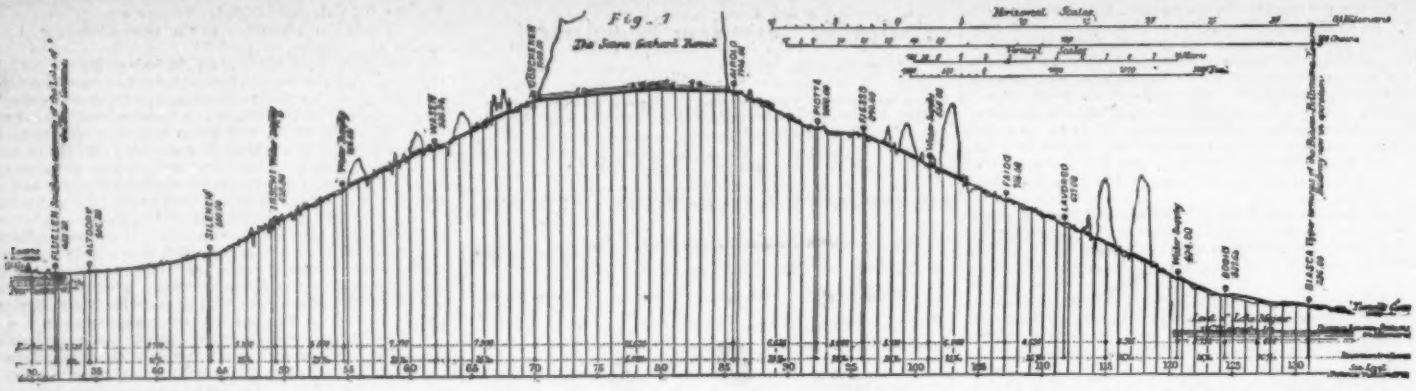
ETHERIC FORCE.

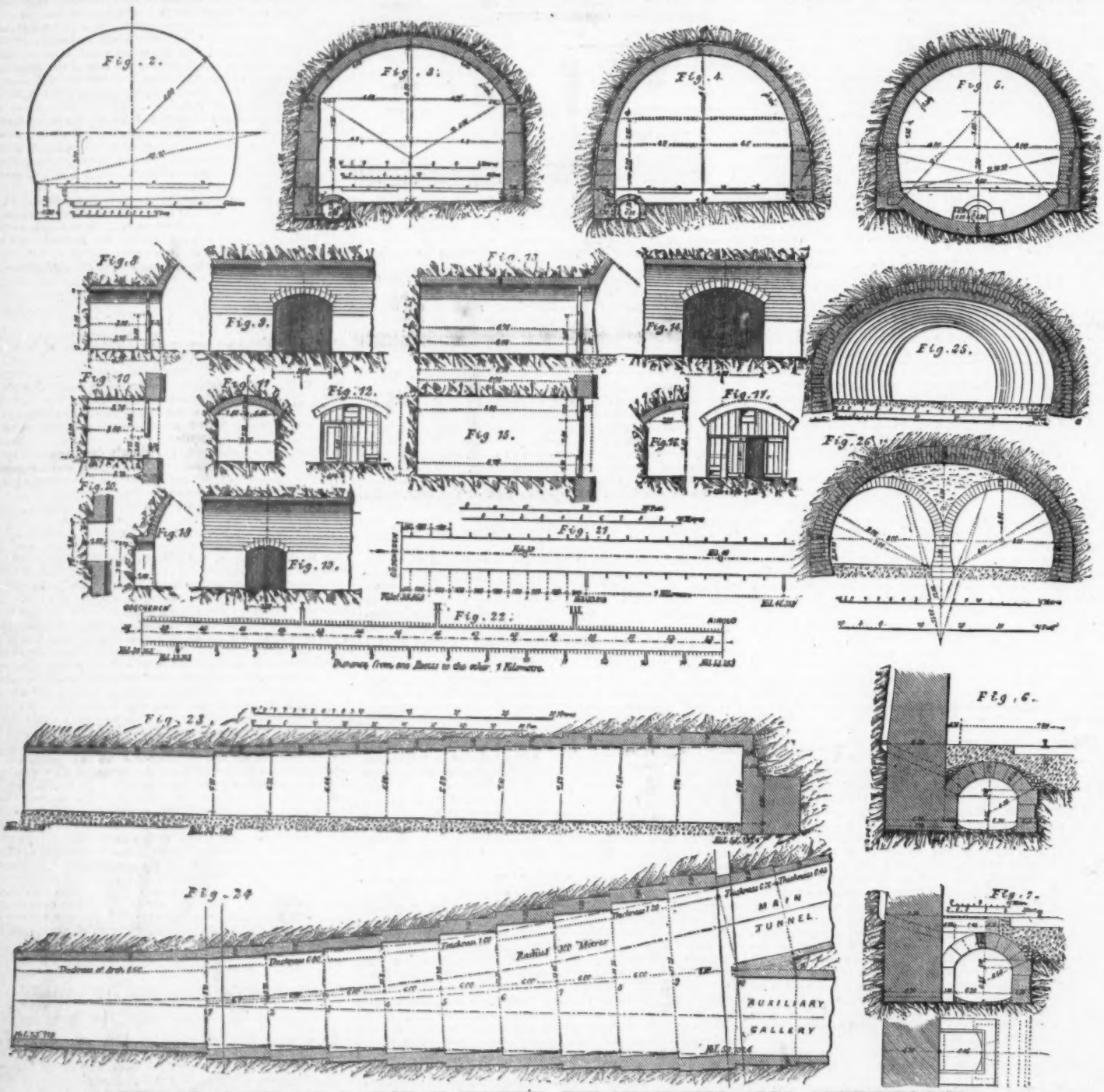
Mr. S. P. Thompson, B.A., B.Sc., then made a second communication "*On the so-called 'Etheric Force.'*" and described some experiments which he has recently made in the Physical Laboratory at South Kensington on the subject. The name was given by Mr. Edison—the inventor of the motograph—to the sparks obtained when a conductor is presented to the core of an electro-magnet, the coils of which are traversed by an intermittent current. The results of the experiments conducted as originally described not proving satisfactory, various other arrangements were tried, and it was found that if the secondary current from an induction coil be used instead of a current direct from the battery the effects are much more marked. When the induced spark was thus diverted, either wholly or partially, into a short coil which was insulated very perfectly from the core inside, a spark about half an inch in length, which has a decided effect on the nerves, could be drawn off from the core, and this was sufficient to illuminate a small vacuum tube; the spark, however, does not exhibit the usual signs of polarity. It was shown by observing the illumination thus produced with a rotating mirror, that the discharge is in reality a reciprocating one, each spark returning on its path after a minute interval of time. Under certain conditions it is also possible to charge an electroscope either positively or negatively by means of the spark, and Mr. Thompson has shown that the spark ignites a jet of gas, but fails to deflagrate metallic wire or ignite gunpowder. From the above and other experiments, which will be exhibited on a future occasion, the author concludes that the cause of the phenomena is obvious, and that the hypothesis of a new force is unnecessary.

ANTHROPOLOGICAL INSTITUTE.—APRIL.

Colonel A. LANEFOX, President, in the chair

DR. COMRIE, R.N., exhibited his collection of weapons and articles of domestic use from New-Guinea, and added several particulars to his previous remarks.—Mr. A. Tylor, F.G.S., read a paper on the origin of numerals. He held that inventive thought had always an object origin, and mentioned measures of length, as space, foot, hand, etc., as having such a source. Also in the Ptolemaic hieroglyphics, a minute or second was shown by an eye-winking, answering to "the twinkling of an eye." Illustrations of the Abacus and mode of calculating by it were exhibited, and shown to be in principle the origin of the modern calculating machine. The dream of a universal language has been realized, as far as numerals and arithmetical figures are concerned, and this is due to their origin.—A paper by Mr. A. L. Lewis was read on some apparent coincidences of custom and belief in Chaldæa and other countries. He alluded, amongst other points, to the marks of finger-nails upon the terra-cotta deeds that had been discovered at Nineveh. They appeared to him to answer to the practice of touching the seals of legal documents with the finger. As regards the belief of the Assyrians in immortality, souls were either united with the sun, or descended to "Bit-Edie" Annwn; the country of the dead, in like manner amongst the Kymry was situated in the lower regions, at the going down of the sun in the west. The children of Anu, or the Sky, in Assyria, may be compared with "Cum Annwn," spirits, believed in by the Kymry. Amongst the Assyrian gods, Hed answered to the Lycian deity "Hu." Civilization appeared to originate with the Turanians, the Semitic race merely succeeding to it.





THE ST. GOTHARD RAILWAY TUNNEL THROUGH THE ALPS, SWITZERLAND.

THE ST. GOTHARD TUNNEL.

THE tunnel of St. Gothard,* passing through the Helvetic Alps, and the length of which will be 9.3 miles, is intended to form the connecting link between two lines of the same name, which, starting from Lucerne, make a connection with the railways of Upper Italy, near the frontier of the Swiss Canton of Tessin. The international treaty concerning the St. Gothard Railway, and concluded on the 15th of October, 1869, between the Swiss Confederation and the Kingdom of Italy, a treaty to which the German Empire added its adherence by the convention of the 28th of October, 1871, settles the political and financial basis of the undertaking. The subvention required for this great work was originally fixed at 85 millions of francs. Switzerland contributed to this sum 20 millions, the Empire of Germany 20 millions, and Italy guaranteed 45 millions. The second report of the directors of the St. Gothard Railway presented to the Swiss Federal Council shows that this subvention, although so great, ought to be considerably increased.

A new and pressing appeal for funds has been made to the countries interested, for the cost of the works already executed far exceeds the original estimate of the whole undertaking, which, from 187 millions, now is increased to 239 millions. The error committed in this estimate has thus reached the almost incredible amount of 102 millions of francs.

The railway system of St. Gothard, which when completed will absorb a considerable part of the traffic from the north toward Upper Italy and the Mediterranean, includes the following lines, which may be easily followed on a railway map of Switzerland: Lucerne-Kussnacht-Immensee-Goldau; Zug-St. Adrien-Goldau; Goldau-Fluelen-Goeschenen; St. Gothard Tunnel; Airolo-Biasca-Bellinzona; Bellinzona-Lugano-Chiasso; Bellinzona-Magadino.

In short, this *réseau*, the length of which is 165 miles, touches the extremity of the Lake Zug, descends by Goldau toward the southern end of Lake Uri, follows the valley of the Reuss, to the northern mouth of the great tunnel (at Goeschenen), traverses St. Gothard, and comes out of the mountain at Airolo (the southern entrance), skirts the valley of Tessin to Lake Majeur, and finally stretches to the Italian frontier.

The St. Gothard Railway in its whole length passes through the five Swiss cantons of Lucerne, Zug, Schwytz, Uri, and Tessin. Italy, as one of the great promoters of the work, is moreover engaged in constructing, on the left bank of Lake Majeur, a line connecting the Swiss railways on the frontier with Lucino, at one of the points of the Italian *réseau* situated on the direct route to Gênes, as well as the connecting link from Chiasso to Camerlata. The contracting parties are also engaged as far as possible in arranging that the branch line to the Gothard *réseau* should be modified to improve the surrounding connections.

According to the international treaty, the Gothard Railway should not, in its summit level, exceed an altitude of 3709.6 feet above the sea; the minimum curves must not be less than 984 feet radius, and the steepest gradients must not exceed 1 in 40. The total length of tunnels, including that of St. Gothard, amounts, according to the last report of the engineer, Mr. Hellweg, to 189,357 feet. The length of tunnel, as compared with the whole line, is thus 23.3 per cent. If from this

* For additional information respecting the progress of the St. Gothard Tunnel and the appliances in use on the work, we may refer to pages 16, 20, and 104.

total the length of the main tunnel is deducted, there will remain 88,560 feet of secondary tunnels.

By the original project, the line from Biasca to Lake Majeur and the Lugano-Chiasso line, having together a length of 42 miles, were to have been finished three years after the formation of the company, and the other lines of the *réseau* the same time as the main tunnel. The period for construction being taken at 2½ years for the lines Lucerne-Kussnacht-Goldau; Zug-St. Adrien-Goldau; Biasca-Bellinzona; Lugano-Chiasso, and Bellinzona and the Italian frontier, with branches to Lucarno; 4½ years for the lines Goldau-Fluelen; Fluelen-Goeschenen; Airolo-Biasca and Bellinzona-Lugano. The time for the completion of the great tunnel was fixed at 9 years.

The following is a summary of the length of the different sections composing the entire line:

	Miles.
Lucerne-Goldau	14.73
Zug-Goldau	9.62
Goldau-Fluelen-Goeschenen	65.70
Airolo and Biasca	35.46
Biasca-Bellinzona-Lucarno	16.33
Bellinzona-Lugano	15.52
Bellinzona-Magadino	16.15
Lugano-Chiasso	163.51
Total length of lines	

The two sections Biasca-Bellinzona-Locarno and Lugano-Chiasso have been in operation since December. The great tunnel of St. Gothard, to which these articles specially refer, had the headings (8 feet 1 inch by 8 feet 1 inch) driven on the 1st of March last for a total length of 6232 yards. As to the four sections, the present financial condition of the company will probably not allow them to be commenced before the powers interested have sanctioned new subsidies. It is hoped, however, that some of the principal tunnels may be set in hand, amongst others those of Bergbahn, Wettingen, Leygistein, Naxberg, Dazio Grande, Faido, Goldau, and Monte Cenere. Some of these are from 3936 feet to 5248 feet in length, and it is proposed to construct them like the larger gallery of St. Gothard.

These preliminary details of the *réseau* being given, we arrive at the consideration of the principal work, commencing by the construction of the gallery as it will be handed over for traffic.

The great tunnel of St. Gothard, which, when completed, will have no parallel excepting that of Mont Cenis, exceeds the latter in length by 8856 feet. The direction of the axis makes an angle of about 5 degrees with the meridian. The northern end of the tunnel (Goeschenen) is 82 feet from the southern extremity of the platform of the station, situated 3637.5 feet above the sea level, and 2204 feet above Lake Lucerne. From this point the line rises with a gradient of 1 in 171 for a length of 24,600 feet, then with a gradient of 1 in 1000 for a length of 4428 feet, where it reaches the culminating point of the tunnel, 3785 above the sea; then, after a length of 1279 feet, it descends with a gradient of 1 in 200, for a length of 3870 feet, where the gradient is reduced to 1 in 500 for 13,792 feet, which brings it to within 984 feet of the platform of the station at Airolo, situated 3755 feet above the sea and 3109 feet above Lake Majeur.

At a point 48,396 feet from the Goeschenen end, the tunnel describes a curve to the east of its axis, so that the gallery for a length of 475 feet is on this curve. For convenience of execution, the tunnel is prolonged in a straight line for a distance of 541 feet towards Tessin, in such a way that the straight tunnel, including this extension, will have a total length of 48,937 feet. These various points are seen upon the longitudinal section, Fig. 1, page 406, which show the line from the Lake of Lucerne, or of the four cantons, to Lake Majeur, including the main and the two approaches. The normal width of the tunnel is 24 feet 11$\frac{3}{8}$ inches at the level of the rails, and 26 feet 3 inches, 6 feet 6 inches above the rails. The roof is semicircular. The floor of the tunnel is formed with a fall of 2½ per cent from each side toward the centre, and at the lowest part is placed a drain 21½ inches deep, the width varying according to requirements. Fig. 2, page 406, is a diagram of the normal section. Up to the level of the top of the sleepers, the floor of the tunnel is filled with ballast. The nature of the revetment varies according to the nature of the rock traversed. Twenty-two different types were designed for this purpose by the convention between the company of the St. Gothard railway and the contractor, M. Louis Favre. Figs. 3 and 4, page 406, represent two forms of linings that have been already adopted in the north and south galleries, the former where the granitic rock occurs, and the latter where the tunnel traverses the crystalline and micaceous schists, of which the mountain is chiefly composed. Section Fig. 5 is to be adopted in passing through disintegrated rocks, but hitherto it has not been found necessary.

The following conditions were agreed upon, relating to the construction and arrangement of the drainage channel. This channel is to be open for the whole length of the tunnel, and is to be of sufficient dimensions to allow free passage for the water, without the latter rising to the level of the underside of the ballast. The channel is, for the most part, placed close to the footings on the left side of the revetment, and it is only to be laid in the axis of the tunnel, in those sections which are formed with an invert. The bottom of the channel is 53½ inches below the top of the sleepers, and has a fall of which the minimum corresponds to the gradients of the rails. In those parts of the tunnel where infiltration occurs, a second drain is made on the opposite side, and is connected with the principal drain by perforated pipes laid under the ballast. Figs. 6 and 7, page 406, show the construction of the drain and sumps.

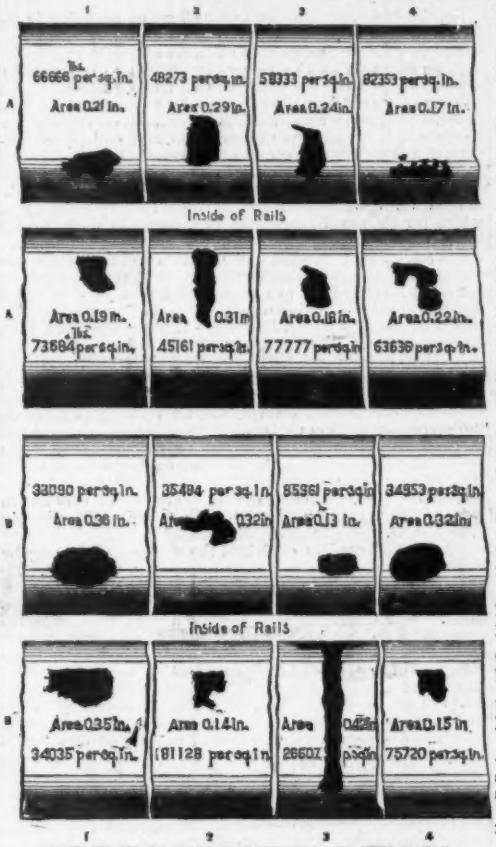
Recesses 6 feet 6 inches high, 39 inches deep, and 6 feet 6 inches wide, are formed in the sides of the tunnel, and opposite to each other, for its whole length, and at intervals of 328 feet. At intervals of 1 kilometre, these recesses are replaced by larger chambers, and at three other points vaults are also constructed. These structures are shown in full detail in Figs. 8 to 20, page 406, and Figs. 21 and 22 are diagrams showing the position of the various chambers.

The ballast in those sections of the tunnel without an invert is 19½ inches thick at one side and 27$\frac{5}{16}$ inches at the other. Where the invert occurs, the ballast is 4 inches at the sides and 67 inches in the centre. The ballast consists of clean hard stones broken to from 1 inch to 2½ inches in diameter. On each side of the tunnel, and for a width of 39 inches, it is formed of smaller stones and clean river gravel. Figs. 23 to 26, same page, show the form and arrangement of revetments at 48,400 feet from the north end of the tunnel, and show also the junction of the straight with the curved gallery which describes, towards the Airolo station, a curve of 984 feet radius.

Such are the general arrangements which regulate the construction of the St. Gothard Tunnel.—*Engineering.*

CONTACT OF LOCOMOTIVE DRIVING-WHEELS ON THE RAILS.

A NUMBER of years ago Mr. Zerah Colburn made some ingenious calculations, which were published in *Engineering*, to determine the amount of the surface of contact of the driving-wheels of locomotives on the rails. Mr. Octave Chanute, when Chief Engineer of the Erie Railway, made some experiments to determine the same question. His method of making the experiments was to raise up the driving-wheel with a jack, place a piece of carbon or manifold paper covered with another piece of tissue paper under the wheel, and then



CONTACT OF LOCOMOTIVE-WHEELS ON THE RAILS.

lower its weight very carefully until it all rested on the paper and on the rail under it. Wherever the wheel pressed hard the carbon paper left its impression in the tissue paper, and thus indicated the extent and form of the surface of contact of the wheel on the rail. We have reproduced a number of these impressions in the engraving herewith, which represents very short sections of the rails with the impressions on them. Those in the two horizontal rows were made on steel rails with an engine having steel tires 4 ft. 6 in. in diameter, and with a load of 14,000 lbs. on each wheel. Those in the first vertical row (numbered at the top and bottom of engraving), in the B B series, were made by an engine with 5 ft. wheels, and having 11,912½ lbs. load on each wheel. The second B B series were made by an engine the tires of which were newly turned and having 4 ft. 7½ in. wheels, each loaded with 11,358 lbs. The third B B series were made with 5 ft. wheels, whose tires were worn, and each loaded with 11,175 lbs. The upper one of the fourth B B series was made by building up a sort of reservoir or dam of moist clay around the tread or point of contact of the wheel, when the latter was resting on the rail, and then pouring sulphate of copper into the reservoir so as to color the rail. When the wheel touched the rail, the sulphate of copper of course could not flow, and therefore if the fluid was drawn off before the wheel was raised, the surface of the rail in contact with the wheel would not be discolored by the sulphate of copper. Although the experiment was carefully tried, it was not regarded as satisfactory, as the fluid would not flow into the extremely narrow crevices by which the surfaces of contact must necessarily be surrounded.

The experiments are interesting as indicating the amount of pressure per square inch on the rails and tires. These have been calculated and are given in the engraving, from which it will be seen that it varies from 26,607 lbs. to 85,961 per square inch.—*Railroad Gazette.*

EXAMINATION OF UNREFINED SUGAR.

"REFINED SUGAR.—On no account buy brown, damp sugar when at little more expense you can procure the refined article. The sugar insect, which infests unrefined sugar, is first cousin to the itch insect. The first-named little creature burrows beneath the skin and causes what is known as grocers' itch, a malady affecting only the hands and wrists of those who handle raw sugars. If a spoonful of raw sugar be dissolved in a wineglass full of water the animalcules will come to the surface, where they will appear like white specks swimming about vigorously. These insects are never found in refined sugar. Crude, raw sugar, infested with these creatures, is not only detrimental to health, but is also the least economical to use. In buying refined sugar you pay for pure sugar crystals only; in buying coarse brown sugar you pay for animalcules, molasses, water, and all sorts of filth. One who has seen the residuum from the filters in a sugar-refinery will never use any but refined sugar. This residuum resembles the black filth of a street-gutter more than any other substance."

A lady housekeeper sends the above alarming paragraph to us, name of paper not stated, wishing our opinion on the same, and also if it applies to molasses as well. We submitted the matter to Prof. William Falke, Professor of Natural Sciences in Manhattan College, New-York City, who reported as follows: About the year 1855 most admirable researches were made upon adulterations of food and medicines sold in London, by the distinguished author, Dr. Hassall, of that city, which appeared partly through the medium of the *Lancet*.

At that time raw and very impure sugars were largely consumed by the London public; refining having been much less extensively practised then than at the present day.

Seventy-two samples of brown sugar were procured from different shops by Dr. Hassall, which were found to contain fragments of sugar-cane in seventy-one in a state of fine division; sporules and filaments of fungus were present in nearly all, and sixty-nine of the sugars contained minute living insects or parasites, which were called *Acarus sacchari*, of which illustrations may be seen below.

A sample of very impure raw sugar examined in Dublin by Prof. Cameron, about the year 1868, was found to be replete with these unsightly little acari, so that ten grains of the sugar harbored five hundred of them, or about one hundred thousand in a pound's weight. Such reports would naturally be well suited for newspaper excitement, and hence every now and then some very nauseous reports are published to portray in vivid colors the nature of our food with its impurities.

Investigations were made of the brown sugars sold by grocers in the retail market, and inquiries respecting the so-called grocers' itch were made. What then was to be done was to visit the various grocery-stores and purchase samples of dark brown sugar of the lowest grade; and in order to do so it seemed natural to obtain them from the poorest sources in ordinary localities. Accordingly, visits were made to unpretending stores in some meagre localities of Harlem and other parts of this city, and brown sugar called for. Great was the surprise when it was found that these stores only sold refined sugar, one nearly perfectly white, and the other of a very light lemon color—the so-called "coffee sugar." Only about eight per cent were found to sell it—that is, a brown molasses sugar—and these were most readily procured from the finer and larger stores, who keep them more by way of variety and completeness of stock.

Microscopic examination of these few samples of brown sugar simply revealed fungus, sporules, and fragments of sugar-cane, with other mechanical impurities. No parasites, however, were found, as these sugars, although unrefined, were quite pure.

It therefore is quite certain that our city is provided with an abundance of pure sugars, and considering that the price of the refined article is so little above the crude material, there is no doubt that the former is the most economical and wholesome for consumption.

Raw sugars from some of the brokers were procured, for one set of which I am indebted to the kindness of Bowerman Bros. of Wall street, in order to examine more minutely into the more impure forms. One of the most remarkable features of these unrefined sugars is the great difference of color and purity which they possess among themselves.

One Mexican specimen was remarkably pure, being of a light yellow color, almost perfectly dry and free from molasses, and devoid of parasites.

One, a Cuban sugar, was exceedingly dark and lumpy, and contained considerable molasses, with broken-down sugar-cane and other organic matter, with a few ova of the sugar-mite, and one living one was found.

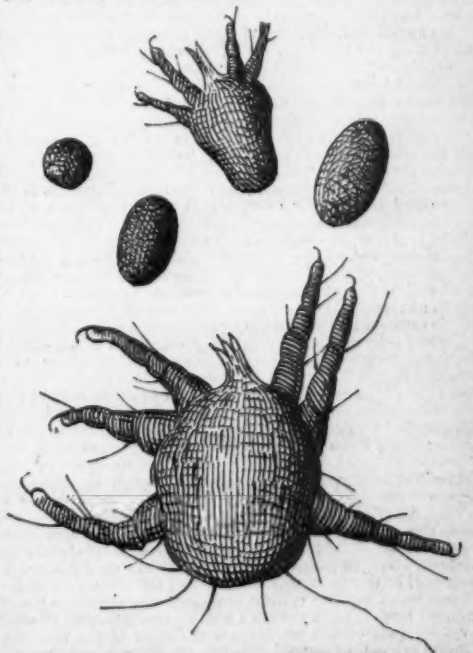
Such impure sugar is not, however, to be obtained in the retail market.

One sample that was designated as Cuba centrifugal—that is, it was freed from molasses and other impurities in solution by means of the centrifugal vat—was very pure and beautifully crystallized.

A Porto Rico sample was quite impure and very heavy, being saturated with molasses, and contained considerable broken-down cane and coloring matter.

Refiners are prejudiced against the beautiful crystallized colonial sugars, and hence the writer was informed that they were not encouraged, for the very obvious reason that their own refined sugars would not be in such extensive demand.

Fine, large-grained sugars are not well suited for the perpetration of certain trade manipulations, known as "mixing" or "handling," which occasionally is resorted to. It consists in mixing sugars of different grades and prices, and thereby obtaining an article which will appear deceptive and yield a superior profit; and for such "handling" fine-grained or even pulverulent sugars are only suitable, as the crystals in the large-grained sugars will crop out and manifest their brilliancy from the inferior mixtures.



THE SUGAR INSECT.—DEVELOPMENT OF ACARUS SACCHARI. REPRESENTING THE OVA, YOUNG AND ADULT SUGAR-MITE. ENLARGED 200 DIAMETERS.

Many substances have been stated to be employed for the adulteration of sugar, as powdered marble, chalk or whiting, bone-dust, starch, potato-sugar, gum, and dextrine.

Such impurities are, however, rarely ever found; for the frauds would be easily detected by simply putting a little of the sugar into some water, whereby it readily dissolves,

leaving the insoluble substances behind, which would remain at the bottom of the vessel.

The value of raw sugars has thus far been determined to a great extent by their color and general appearance, and a standard of comparison has been employed consisting of various grades called the "Dutch standard," which enables speculators to pass a high-graded sugar through under the guise of a low grade, by simply coloring the sugar by artificial means before entering the market, and afterward refining.

There is no reason to doubt that fine and pure sugars would enter the market abundantly if the sugar-growers could find a sale for it; but as it is, "home manufacture and refining must be encouraged."

The so-called grocers' itch, to which many other classes of business occupations may give rise, is an affection of the hands and wrists, one of the symptoms of which is an unpleasant irritation and itching of the skin. It is not a parasitic disease, and is not produced by the sugar-mite, as at first was merely supposed, but is what dermatologists call eczema, and which, in the case of grocers, is generally produced by handling dry and irritating substances.

Heber, the distinguished German dermatologist, states that grocers are sometimes affected with the genuine itch, which is produced by a very different parasite—called *Larcoptes scabiei*, which affection has no doubt been also mistaken as being produced by the sugar-mite.

On the whole, we may then conclude that the sugar of our retail market is in an excellent condition; unrefined sugar being little in demand, and sugar parasites well-nigh obsolete.

Coffee, however, in particular the ready-ground, is the crying evil in this large city.

CONCRETE AS A BUILDING MATERIAL.

IN our SUPPLEMENTS Nos. 13 and 20 will be found drawings and descriptions of cottages and other buildings, made of concrete, with description of the methods of employing this material. At a recent meeting of the Royal Institute of Architects, London, Mr. A. Payne delivered a lecture upon the subject.

The lecturer introduced his subject with a review of the present position of concrete building, and noticed the principal patents that have been taken out in reference to it of late years, arranging them under the heads of 1st, apparatus for moulding walls; 2d, the various kinds of building-blocks; and, 3d, composition for making concrete. On looking at the results of these inventions, he feared that it must be admitted that they had not done much towards striking out a new line for the employment of concrete, although they might have improved the material. By far the most common mode of concrete building still practised, and perhaps the best for most purposes was the old method, described by Alberti, of placing planks on each side of the intended thickness of the wall, and pouring pebbles and mortar between, moving the boards when the compound had set. It was conceded on all hands that concrete buildings are durable, strong, dry, and not expensive; but the general outcry was that they were ugly. The question arose, Was this ugliness owing to some inherent deficiency in the material, or to the neglect of the subject by architects, and to the endeavor being made to mould the material into shapes and forms that had been employed in brick and stone, built up in a totally different way? He was afraid the latter causes had the most to do with the adverse opinion that had been pronounced upon the appearance of concrete structures. Mr. Payne proceeded to give some suggestions for the architectural employment of concrete in the future, arranging them under the three following heads:—1. How can the apparatus for moulding and constructing concrete walls, roofs, and arches be simplified and turned to artistic account? 2. Does not iron offer special advantages for use in connection with concrete? 3. What is the proper way to ornament concrete walls, arches, and roofs, in accordance with the peculiar properties and nature of the material? Under the first head it was suggested that the apparatus for moulding concrete buildings might be frequently made a permanent part of the structure by forming a light skeleton framework of wood or iron, of ornamental design, for supporting temporary moulding boards, and then filling up with concrete. Under the second head it was stated that no two materials were so well suited to go together as iron and concrete. With the one a skeleton framework could be made of almost any dimensions, and of great strength and lightness; and in the other architects had a plastic material that could be readily moulded to any shape, and could be made to enclose the skeleton, and give it substance and solidity. It was well known that if iron was bedded and kept from the air it was entirely protected from rust and oxidation. But, more than this, iron was just the material to give to walls the tensile and binding strength that they lacked, to counteract the failure that most commonly took place in brick and stone construction. As to the ornamental appearance of houses built in iron and concrete the effect would not be unlike that of the half-timbered houses of the middle ages. The ironwork would, however, be capable of greater freedom of treatment than the ancient woodwork. Under the third head the lecturer submitted that, instead of imitating the projections of stone and brickwork, the aim in concrete work should be to obtain as large wall spaces as possible, and as few projections, and to ornament by preference by indentations. In his opinion there had been no building material employed which offered such facilities for rich ornamentation, by this means, at a comparatively trifling cost, as concrete. It was pointed out that most of the magnificent decorations of the Alhambra and the Mahomedan buildings of India were produced by incised ornament of this description; he thought that there could be no better nor more suitable method for ornamenting a concrete façade. Examples were given of the manner in which this might be effected by movable dies fixed in the moulding boards used in concrete construction. This method was in reality bringing the principle of the printing press to bear upon the ornamentation of a building, and had its practical as well as artistic side, by substituting letters for ornamental designs. Where permanent advertisements or records were required, or where it was desired to preserve an account of the origin or purpose of any building, why should not such account be printed in the solid wall in concrete, and be made to form part of the structure and design of the building? Could they not, in fact, in this respect often advantageously follow the example of Assyria and Egypt, and, without going back to cuneiform characters or hieroglyphics, still usefully record in their buildings the purposes for which they were erected? It was also shown how by the same method a veneer of tiles, marble, or plaques of a particular shape might be bedded in the surface of the walls, and how the stone and flint panelled work of Essex and Suffolk might in the same way be readily done in concrete. Plastic decorations and sgraffito were referred to as being eminently suitable for the decoration of concrete, and the authorities of the South Kensington Museum were said to have rendered good service to the English public by giving practical illustrations of the beauty that might be obtained by this mode of decoration, at the back of the Science and Art Schools, at Kensington, and at the National Training School for Music, adjoining the Albert Hall. [Both these examples have been recently illustrated in the *Building News*.] The paper, which was unusually brief and concise, concluded by reference to examples and illustrations, hung upon the walls of the rooms, of the methods suggested for the employment of concrete, and showed how they could be advantageously applied to domes, vaults, piers, and other structures.

Mr. Charles Barry said he had had great hesitation in attempting to use concrete, or permitting its use as a building material, not from any want of confidence in its strength, but because of the difficulty of insuring that those who actually dealt with it were experienced and trustworthy men and masters of the subject. One of the most valuable suggestions in Mr. Payne's paper was the idea thrown out of forming the framework of the structure in thin iron, and entirely embedding this in a close-fitting coat of concrete. It was of course well known to those present, that the principle of using iron in connection with something like concrete, had been adopted in the dwellings for the working classes, built by a society of which Sir Sydney Waterlow is president. In these houses the steps, landings, beams, and lintels were of concrete, with a thin bar of iron imbedded in them. He did not think the use of concrete was attended with danger if thoroughly well done, but if it were left to inexperienced men by contractors desirous merely of getting over their work, it seemed to him that it offered greater facilities for scamping the work than other materials. Its use was attended with the more danger, as, when concrete failed, it gave way altogether, and suddenly, and showed no previous signs of weakness like brick, or stone. He questioned whether economy could be found in the use of the dies, stamps, &c., for forming patterns on the surface of walls of this material, such as the lecturer had referred to. He wished that Mr. Payne had given them figures as to its relative cost. He had spoken very glibly of "throwing in concrete" when frames were set, but if incised ornaments were to be used, the material must be very fine in quality, and very carefully mixed. Here, again, the question of cost arose.

Mr. W. H. Lascelles explained the system of building by concrete slabs, which has been patented in his name. He stated that he erected a framework of timber. To this were fastened slabs of concrete, formed of breeze and Portland cement. These slabs were cast in wooden moulds, with tile-like projections, and set in four days. They were strengthened by a thin iron rod at the back, and colored with Spanish brown. They measured 3 ft. by 2 ft. in width, and were 1¼ in. to 2 in. thick. Including the iron rod they cost 1s. 6d. each, or 8d. per foot superficial. The proportions were four of breeze to 1 of Portland. He claimed for the slabs thus made that they were water-tight and fire-proof, and stated that sashes could be made in the same manner, and would bear nails and screws being driven into them as well as wood. Slabs of the same material could be fixed as roofs. Another series of slabs would form the ceiling to one room and the floor to that above. He had formed joists of concrete, but found that they cost as much as wood. Such a house cost 20 per cent. less than a similar one of brick. The system was well adapted for use in conservatories. Specimens and models of a tile-and-framed cottage, of iron and concrete sash bars, and of flooring materials were exhibited and explained. Mr. Lascelles was subjected to close questioning by Messrs. Cates, Whichcord, Barry, and Anderson, as to the durability and completeness of buildings erected under his patent, and concerning their resistance to fire and water, the possibility of driving nails into them, etc. He further explained that the spaces between the timber studs produced a panelled appearance within, and that the slabs could be cast to almost any dimensions.

Mr. Redmayne thought there was great force in what Mr. Barry had said as to the danger of the indiscriminate use of concrete. Experience had, however, been learned from its use in engineering, and the casualties that attended its first introduction into use, and, after the long series of tests that had been applied to it, it was too much to expect that concrete would become of great use in building. Although concrete had been known from the earliest times, its use in this country was of comparatively modern origin, having been first used for foundations in 1811. Mr. Redmayne proceeded to trace its use in the construction of pier foundations, dock walls, and quays at Dover, Chatham, Woolwich, Deptford, and other ports from that period to the present time.

Mr. T. Blashill asked in what way Mr. Payne contemplated dealing with the shrinking or expansion of timbers bonded into his concrete walls, and also what was the effect of the condensation of moisture upon them, as they were impervious to water? The late Mr. Charles Fowler had said that he built a chapel of concrete, whose roof was 14 in. thick, and that when people congregated in it the moisture condensed and dripped from the roof. Mr. Lascelles' system appeared to resemble the old weather tiling, once common in Kent. The chief question was, whether it cost more or less than brickwork.

Mr. Nash thought, notwithstanding the immense antiquity of concrete, there was much to learn about it. He had great doubts as to the homogeneity of concrete walls with iron rods in them, chiefly because of the gradual settlement of the concrete. Although, when first made, concrete expanded, yet as it set he had found that it gradually shrank, both laterally and perpendicularly. This could be seen in the long range of concrete seawall at Bognor, through which they could see fissures at every 70 or 100 feet, produced by this cause. He thought that they must, therefore, work in concrete with caution.

Mr. Banks had considerable experience in dealing with concrete some two or three years since, and the more he saw of it, the less he liked it as a building material. At the same time, architects should study it, as it appeared to meet a want of the age, and could be manufactured from refuse, and even, General Scott told them, from sewage. The great disadvantage in its use was its gradual contraction, and that it was impossible to say when this shrinkage would cease; another difficulty was that concrete could not be insured to be all of the same quality. Attempts were being made to utilise the refuse slag from ironworks in its manufacture, and he believed that these would prove successful, so far as hematite slag was concerned.

Mr. Thomas Broughton explained, by means of a model, his patent appliances for erecting concrete buildings by means of tubular slotted frames, in which ordinary scaffold or other boards can be fixed and secured. In reply to questions from Mr. Payne, he stated that wood joists were not injured by being secured into concrete, nor had he known such walls to fall, nor did difficulty arise from the condensation upon the walls.

Mr. Alfred Giles, as an engineer, had used concrete for a great number of years, and thought that the result of using iron framework would be very unsatisfactory. In using concrete for quay walls he had never been able to complete any considerable length at a time, owing to the fissures formed by its shrinkage in settlement. He thought its economy as against brickwork would show better in large than in small quantities.

RADIOMETERS.

THESE novel instruments have recently, as our columns testify, attracted considerable attention, not only amongst scientific amateurs but also amongst savants in different parts of the world. Since Mr. Crookes introduced the subject to the Royal Society, several communications have been submitted to that learned body, and to some of these and to certain outside critics the inventor of the instrument has now replied. At the meeting of the Royal Society, on March 23d, Dr. A. Shuster read a paper on the "Nature of the Force producing the Motion of a Body exposed to Rays of Heat and Light," of which the following is an abstract:

Mr. Crookes has lately drawn attention to the mechanical action of a source of light on delicately suspended bodies *in vacuo*; I have made a few experiments with the view of finding out the seat of the reaction which evidently must tend to move either the inclosure or the source of light. I have found that the action and reaction is entirely between the light bodies suspended *in vacuo* and the exhausted vessel.

Mr. Crookes' "Light-Mill" was suspended by means of two cocoon fibres, forming a bifilar suspension from the top of a vessel which could be exhausted. A slight movement of the inclosure could be easily detected by means of a concave mirror attached to it. A beam of the oxyhydrogen lamp was concentrated on the light-mill, which then revolved 200 times a minute. The light was cut off at the beginning of the experiment by means of a screen, and the position of rest of the glass vessel was read off by means of the dot of light on the scale. The screen was then suddenly removed, and in every case a large deflection of the glass vessel was observed. The vessel was deflected in the opposite direction to that in which the mill turned. When the velocity of the mill had become constant, the vessel turned to its original position of rest, but on suddenly cutting off the light the vessel was again deflected, but in the opposite direction as on starting the experiment. The vessel, therefore, now turned in the same direction in which the mill turned.

These experiments are easily explained on the assumption that the force acting on the vessel inclosing the light-mill is exactly equal and opposite to that acting on the mill itself. While the velocity of the mill in one direction is increasing, a force acts in the opposite direction on the vessel. When the velocity has become constant, the force which tends to drive the mill round is exactly counterbalanced by the resistance which opposes the motion of the mill. The two forces acting on the vessel will therefore counterbalance, and the vessel will return to its original position of rest. When the light is cut off, the resistance will stop the motion of the mill. The reaction of the resistance will act on the inclosure, and the inclosure will turn in the same direction as the mill. By means of the reaction on the inclosure I have been able to calculate the strength of the force; and I have found that the pressure on a surface on which the light of equal intensity to that used in my experiments falls is equal to that produced by the weight of a film of water equal in thickness to the length of a wave of violet light.

At the last meeting of the Royal Society Mr. Crookes read a paper on the "Movement of the Glass Case of a Radiometer," in which he said: During the discussion which followed the reading of Professor Reynold's and Dr. Shuster's papers at the last meeting of the Royal Society, I mentioned an experiment bearing on the observations of Dr. Shuster. I have since tried this in a form, and as the results are very decided and appear calculated to throw light on many disputed points in the theory of these obscure actions, I venture to bring a description of the experiment, and to show the apparatus at work, before the society.

A large radiometer in a four-inch bulb was made with ten arms, eight of them being of brass, and the other two being a long watch-spring magnet. The discs were of pith, blackened on one side. The power of the earth on the magnet is too great to allow the arms to be set in rotation unless a candle is brought near, but once started it will continue to revolve with the light some distance off. This radiometer was floated in a vessel of water and four candles were placed round it, so as to set the arms in rotation. A mark was put on the glass envelope so as to enable a slight movement of rotation to be seen. The envelope turned very slowly a few degrees in one direction, then stopped and turned a few degrees the opposite way; finally it took up a uniform but excessively slow movement in the direction of the arms, but so slow that more than an hour would be occupied in one revolution.

A powerful magnet was now brought near the moving arms. They immediately stopped, and at the same time the glass envelope commenced to revolve in the opposite direction to that in which the arms had been revolving. The movement kept up as long as the candles were burning, and the speed was one revolution in two minutes. The magnet was removed, the arms obeyed the force of radiation from the candles, and revolved rapidly, whilst the glass envelope quickly came to rest and then rotated very slowly the same way as the arms went.

The candles were blown out; and as soon as the whole instrument had come to rest, a bar-magnet was moved alternately from one side to the other of the radiometer, so as to cause the veins to rotate as if they had been under the influence of a candle. The glass envelope moved with some rapidity (about one revolution in three minutes) in the direction the arms were moving. On reversing the direction of movement of the arms the glass envelope changed direction also. These experiments show that the internal friction, either of the steel point on the glass socket, of the vanes against the residual air, or of both these causes combined, is considerable. Moving the vanes round by the exterior magnet carries the whole envelope round in opposition to the friction of the water against the glass.

As there is much discussion at present respecting the cause of these movements, and as some misunderstanding seems to prevail as to my own views on the theory of the repulsion resulting from radiation, I wish to take this opportunity of removing the impression that I hold opinions which are in antagonism to some strongly urged explanations of these actions. I have on five or six occasions specially stated that I wish to keep free from theories. During my four years' work on this subject I have accumulated a large fund of experimental observations, and these often enable me to see difficulties which could not be expected to occur to an investigator who has had but a limited experience with the working of one or two instruments.—*English Mechanic.*

METHODS OF CHEMICAL RESEARCH.

By Dr. ANDREWS, F.R.S., before the Chemical Society.

THE lecturer began by describing the simple form of apparatus which he employed many years ago in his researches on the heat evolved in the combination of oxygen, chlorine, bromine, etc., with other bodies. In every case the bodies to be combined were inclosed in a vessel surrounded with water, and the combination was effected either by the ignition of a fine platinum wire, or, where they acted directly upon one another, by the fracture of a glass capsule containing one of the combining bodies, the heat being measured by the rise of temperature of the water. He next referred to the arrangement by which he had been the first to decompose water so as to render visible the hydrogen and oxygen, and to measure their relative volumes by means of atmospheric electricity and of electrical currents from the ordinary machine. For this purpose fine platinum wires were hermetically sealed into fine thermometer tubes, which were then filled with dilute sulphuric acid by withdrawing the air by ebullition. The same current of frictional electricity will decompose the water in almost an indefinite number such couples arranged in a consecutive series. Capillary tubes of this kind may be employed for eudiometric experiments, which would be exceedingly tedious in wide tubes. Thus oxygen gas can at once be absorbed by passing the silent discharge through it while standing over a solution of iodide of potassium. By means of the air-pump it is easy, with a gentle exhaustion, to expand the gas so that it may fill the whole tube while the open end is immersed in the liquid which it is desired to introduce; on removing the pressure the gas will be in contact with the new liquid.

The lecturer exhibited some of the original tubes with which Prof. Tait and he first determined that ozone is a condensed form of oxygen, and explained a form of apparatus by means of which this important fact can be exhibited as a class experiment. A full description of this apparatus will be found in his lecture on ozone, which was delivered some time ago before the Royal Society of Edinburgh, and has since been published by the Scottish Meteorological Society. With this apparatus, the lecturer has been able to determine that chlorine gas undergoes no change of volume from the prolonged action of the electrical discharge. His experiments on this subject have not yet been published, but they were made under singularly favorable conditions for discovering a very small change of volume in the gas if any such change had occurred.

The lecturer in the next place briefly alluded to the method he formerly employed for determining the latent heat of vapors, of which a detailed account was given in a former communication to the Chemical Society. The apparatus employed admits of exact experiments being made on a small scale, and consequently on substances in an absolutely pure state, an object of even greater importance in inquiries of this kind than in ordinary chemical analyses. He remarked that a large field for investigation in this part of the domain of science lay comparatively uncultivated, and would yield a rich harvest of results to any one who would enter upon it.

Passing from this subject, the lecturer described a dividing and calibrating machine which he contrived some years ago for the special work in which he has been engaged, and which has given to many of his investigations an accuracy otherwise hardly attainable. He has been enabled by means of it to construct thermometers whose readings are absolutely coincident throughout every part of the scale, and to calibrate with almost perfect accuracy the glass tubes used in his pressure experiments. It would be impossible in an abstract to describe the construction of this machine, but it may be important to mention that the screw which moves the microscope or divider is a short one of remarkable accuracy, constructed by Troughton & Simms.

The last subject treated was the lecturer's method of investigating the properties of gaseous and liquid bodies at high pressures and under varied temperatures. By means of his apparatus, which was exhibited to the meeting, pressures of 500 atmospheres can be readily observed and measured in glass tubes—in a word, a complete mastery obtained over matter under conditions hitherto beyond the reach of direct observations. This has been effected by a novel mode of *packing* a fine steel screw, so that while entering a confined portion of water no leakage whatever occurs under enormous pressures, and also by a peculiar method of forming a tight junction between glass and metal. The lecture was concluded by a short statement of the more important results lately communicated to the Royal Society on the properties of matter in the gaseous state.

GALLIUM—A NEW LIQUID METAL.

By M. LECOQ DE BOISBAUDRAN.

I HAVE just reduced to the metallic state about 10 centigrms. of gallium, which I believe is very sensibly pure. As I have stated, the first specimen of gallium presented to the Academy owed its solidity to the presence of a small quantity of foreign metals. Pure gallium melts at about 29.5°, and is, therefore, liquefied when held in the fingers; it remains very readily in super-fusion, which explains how a globule remained in the liquid state at temperatures falling at times as low as zero. Gallium obtained by the electrolysis of an ammoniacal solution is identical with that prepared by means of a potassic solution. When once solidified the metal is hard and resistant, even at temperatures little below its melting-point. Nevertheless, it is sectile, and possesses a certain degree of malleability. Melted gallium adheres readily to glass, on which it forms a fine mirror, whiter than that produced by mercury. If heated to bright redness in presence of air, gallium is only oxidized very superficially, and is not volatilized. In the cold it is not sensibly attacked by nitric acid, but with the aid of heat it dissolves with the evolution of red fumes. The specific gravity of the metal, determined approximately on a specimen weighing 64 milligrms., is 4.7 at 15° C., with respect to water at the same temperature. The mean sp. gr. of aluminium and indium is 4.8 at 0°. The specific gravity agrees, therefore, with theoretical prevision, but its extreme fusibility is a fact totally unexpected. For the other properties of gallium I must refer to my sealed packet, dated March 6th, and to my former communications. With the permission of the Academy I will shortly describe certain new reactions of the compounds of gallium, and point out the method to be followed for its extraction from ores.

M. Wurtz laid before the Academy three specimens of gallium, one of them in a state of super-fusion, and demanded, in the name of M. Lecoq de Boisbaudran, that the sealed packet in question should be opened. This having been accordingly done by the Perpetual Secretary, it was found to contain the following paper:

"The specimen of gallium which I had the honor of presenting to the Academy had been obtained by the electrolysis of an ammoniacal solution of sulphate of gallium. The metal thus prepared was solid, and even rather hard. Its solution in hydrochloric acid gave the rays of gallium with brilliance, and those of zinc much more feebly. The metal, therefore, was gallium containing, according to the indications of the spectrum, small quantities of zinc and insignificant traces of other metals.

"The solubility of oxide of gallium in ammonia not being great, I sought for some other solvent which might enable me to obtain concentrated solutions suitable for electrolysis. Caustic potassa dissolves a large quantity of oxide of gallium: this solution readily undergoes electrolysis, but the metal obtained by this process is liquid, and not solid like that obtained from an ammoniacal solution.

"The following observations have been made on about 1 milligrm. of liquid gallium:

(1.) A very small globule, exposed to the open air for more than three weeks, lost neither its liquidity nor its metallic lustre.

(2.) The metal is deposited upon a negative electrode of platinum as a dead, whitish grey coating formed of numerous minute globules. It dissolves in the cold in dilute hydrochloric acid with brisk disengagement of hydrogen.

(3.) The hydrochloric solution of the metal yields a fine spectrum of gallium; along with the zinc rays more feebly. The latter are less marked than with the solid gallium from the ammoniacal solution.

(4.) The residue from the limited evaporation of the hydrochloric solution of the liquid metal is neither colored by iodide of potassium, nor by ammonia, nor by hydrosulphate of ammonia. The dry residue from the evaporation was nevertheless sufficient to be distinctly visible. Mercury, therefore, is not present.

(5.) Liquid gallium, deposited by electrolysis upon a small piece of platinum, was heated to redness, or almost to redness. It adhered and doubtless became alloyed with the platinum, and resisted the action of hyrochloric acid, but it was attacked by weak *aqua regia* along with a little of the platinum; the solution showed the rays of gallium. A slight whitish pellicle, insoluble in *aqua regia*, was detached from the platinum; this was, perhaps, oxide of gallium rendered insoluble by ignition.

"At the time of those experiments I still had a portion of the gallium which I had presented to the Academy, and which had been returned to me. I made use of it to satisfy myself anew of the hardness of this gallium, and of the nature of its spectrum, which I found as before was composed of brilliant gallium rays, feeble zinc rays, and insignificant traces of other metals.

"We can not ascribe the liquidity of the gallium obtained by the electrolysis of a potassic solution to the presence of a small quantity of potassium reduced by the voltaic current, since the alkaline metal would have been quickly oxidized, both during the washings and by contact with moist air. I think, therefore, that pure gallium is really liquid, and if I obtained it at first in the solid state it was probably by reason of its being alloyed with small quantities of other metals, especially zinc. Solid gallium is, in fact, less pure than liquid gallium. The solidity of gallium seems to be caused by relatively inconsiderable quantities of foreign metals.

"We may still suppose that by the electrolysis of an ammoniacal solution there is deposited, not pure gallium, but a compound of the metal with the elements of ammonia—a hydride, amidide, or nitride.

"I eagerly await the time—I hope not far distant—when, having at my disposal several centigrms. of purified gallium, I shall be able to determine its physical properties, which promise to be interesting."—*Comptes Rendus—Chemical News.*

EFFERVESCING PREPARATION OF SODIUM TARTRATE.

By HENRY T. HAYHURST, Ph.G.

WITHIN a few years past, an effervescing solution of sodium tartrate has been slowly gaining confidence among physicians as an active cathartic and purge, superior to solution of magnesium citrate, among the people as a cooling beverage and agreeable cathartic, and among pharmacists as an elegant, permanent, and profitable preparation. Its superiority over solution of magnesium citrate lies principally in the following qualities: It does not debilitate the bowels, and leave them in a weakened condition. It does not produce tenesmus, and therefore can be used with much less pain, as a purge, where hemorrhoids are present, than the magnesia solution. It is a permanent solution, and does not precipitate nor become cloudy, after a few days, as the magnesia solution frequently does. It is as palatable and pharmaceutically elegant as the magnesia solution, superior to it in medicinal value, and of much more profit to the pharmacist in manufacturing.

The formula which I have ascertained to give the most stable product and gratifying results is the following, namely:

Take of sodium carbonate,	℥i ʒii
acid tartaric, in crystals,	ʒvi
oil of lemon,	gtt. iii
simple syrup,	f℥iss
pure water, q. s. ft.	f℥xii

The operation is as follows: reduce the sodium carbonate to powder, rub the oil of lemon intimately with it, and then add water sufficient to dissolve; to this solution add five drachms of the tartaric acid, and stir occasionally till the acid is dissolved. Filter this solution to remove any impurities which may be present, or any cloudiness resulting from the introduction of the oil of lemon. To this filtrate add the syrup, agitate thoroughly, then add one drachm of tartaric acid (the remaining amount), cork and tie immediately to preserve the carbonic-acid gas; finally, agitate the contents of the bottle occasionally till the acid is all dissolved, and keep in a cool place cork downwards.

The reasons for using the acid in crystals for producing the tartrate, are these: The commercial powdered acid usually contains impurities, and sometimes adulterations, not present in the crystals; to powder them previously to adding to the alkaline solution would be an unnecessary occupation; finally the reaction is performed much slower and more regularly than where the powdered acid is used, an object, I think, greatly to be desired in processes evolving much carbonic-acid gas. The last portion of the acid could be added by dissolving it first in the syrup and adding this solution, but in doing this the reaction is severe and instantaneous, so that much gas is often lost, while with the crystals the reaction is moderate, and sufficient time is given for inserting the cork, and for the gas to dissolve in the liquid.

Prepared in this manner, effervescing solution of sodium tartrate is a very agreeable beverage, and can be preserved unimpaired for most any length of time, samples having been kept through the hot months uninjured.

I have found such a wide difference in samples of sodium carbonate, obtained from different establishments, in regard to purity, efflorescence and amount of water of crystallization, that I have purified and recrystallized this salt, much to my satisfaction, and it will fully repay pharmacists to adopt the following plan:

Dissolve the large crystals of common sal soda in pure water, allow all the insoluble impurities to subside, filter this solution and evaporate at a moderate heat till a pellicle forms over the surface of the liquid, and set aside for two or three days to crystallize. A small proportion of mother liquor remains, which, if sufficiently pure, may be still further evaporated and crystallized, if desired. These crystals should now be dried on a linen strainer in a moderately warm air-chamber, much care being necessary in this operation, as the crystals effloresce readily in the atmosphere, and too much heat will easily liquefy the salt again. This process yields beautiful, clear, oblique-rhombic, prismatic crystals, which should be preserved in well-stopped jars. It may contain some sodium chloride and sulphate, which, however, if in minute quantity only, do not detract from its medicinal value.

An effervescing granular salt of sodium tartrate may be formed by heating, on a sand bath, anhydrous sodium carbonate and pure powdered tartaric acid, in the proportion of three parts of the alkali to four and a quarter of the acid. Care must be taken to do this in a vessel not affected, chemically, by tartaric acid, and to keep the chemicals well stirred and scraped up from the bottom, or they will become yellow and carbonized. This gives an agreeable, slightly acid salt, very soluble in water, which solution effervesces briskly, and forms a convenient and pleasant cathartic and cooling drink. This preparation keeps well and does not attract moisture, as do many effervescing granular salts.

For a cooling drink the solution may be taken in tablespoonful doses hourly, as a mild cathartic one half a bottleful, and for a brisk purge a whole bottleful. The granular salt may be taken in teaspoonful or tablespoonful doses, dissolved in sweetened water.—*American Journal of Pharmacy.*

PRESSED HERBS.

By J. U. LLOYD, Cincinnati, O.

HERBS are pressed to reduce their bulk; they then are compact, require but little space for storage, and are easily handled. If I mistake not, I have named about the only advantages pressed herbs possess over loose.

My experiments teach me that they deteriorate nearly, if not quite, as rapidly when pressed as loose. In either case, they are exposed to the action of the atmosphere, and the decomposing effects of the moisture with which it is usually laden. Insects attack both. Pressed herbs, without a doubt, mould quickest. Excepting the mere matter of bulk there is no inducement for pressing herbs. Common paper bags, or even cotton sacks, will preserve them as well. The desideratum of the day is a process for preserving the delicate medicinal principles of our herbs from season to season. If this can be accomplished, in conjunction with compactness of form, so much the better; otherwise let us choose quality first, even though it be at the sacrifice of convenience in handling.

In the proceedings of the American Pharmaceutical Association, 1875, we find an article from the pen of Mr. A. W. Miller, upon an improved method for preserving herbs, said improvement being the substitution of pasteboard boxes for paper. The herbs, instead of being pressed by the dealers into compact masses, as is now customary, are, by the pharmacists themselves, firmly packed into the box by hand, remaining loose enough to admit of examination at any time. In my opinion, the important point in connection with dried herbs is preservation, not convenience. Is there any advantage to be derived, in this respect, from the substitution of pasteboard boxes for our machine presses, or even paper or cotton bags? Will boxes prevent the ravages of insects, or preserve the delicate organic principles upon which many of our herbs depend for their medicinal values? This is the direct issue, not convenience in packing, and the value of shelf room.

Personally, I have met with many aggravations respecting loose and pressed herbs, barks and roots, as found upon the market. Necessity has compelled me to experiment upon their preservation. The subject is very important to every druggist and pharmacist, and I feel that a brief description of the most successful of my experiments will be of interest to many readers of the "Journal." To preserve herbs with any satisfaction, I was compelled to use air-tight tin cans. Gather the herb when in its prime, quickly and carefully dry it, then, by hand, press it into the can, sprinkle upon it chloroform, in the proportion of half an ounce to each pound, replace the cover immediately and render the can air-tight by painting the edges with melted beeswax. Herbs like peppermint, spearmint, etc., which depend for their virtues mostly upon delicate essential oils, can be nicely preserved in this way. Roots and herbs that are particularly liable to the attacks of insects, *e.g.*, parsley root, burdock root, motherwort, will show no sign of their presence. Is there any objection to chloroform in this connection? I think not; it is quickly dissipated when exposed to the atmosphere; it certainly is of much value, insect life being destroyed by its vapor; without it, even though in air-tight cans, specimens will be attacked. Aside from this, I believe the vapor of chloroform exerts a preservative influence over most of the delicate proximate principles of our plants.

Any druggist can have tin cans made to order, at small expense; with careful handling they will last many years, being refilled each season. Of course the process necessitates some trouble, and when the customer is waited upon, a little time must be consumed in replacing and waxing the cover. It is time well employed, however, for the majority of customers will prefer paying double the price of ordinary herbs for those preserved in this manner.

The season is now approaching for replenishing the stock of botanical specimens. This stock must last until next year. Druggists can gather many articles they will otherwise be compelled to purchase. Pharmacists who knowingly will not allow a grain of other inferior and adulterated medicines to enter their stores, are compelled to dispense from their counters, each year, a large amount of old and worthless pressed herbs, often mouldy, and usually full of stems, sticks, dirt, etc. They must take what the market affords, unless they gather prime articles at the proper season. But it may be well to remember that prime herbs in August are entirely different materials the following January, unless precautions are taken to preserve them.

The process of preserving herbs in tin cans, by means of a little chloroform, was suggested to me by the late Prof. W. B. Chapman, of Cincinnati, who had met with remarkable success in applying it to ergot.—*American Journal of Pharmacy.*

HOW TO BUILD CHEAP BOATS.

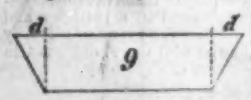
By PADDLEFAST.

No. 2.

THE following directions are for the construction of a skiff to carry four persons. If built for rowing alone, the cost of materials will be about five dollars. It is easily built, but more difficult than the scow described in our last article. Its sharper bow facilitates speed.

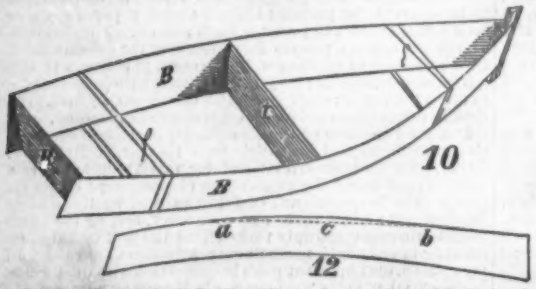
A FIVE DOLLAR SKIFF.

Ten or eleven cedar boards ¾ in. thick, and not less than 7 in. wide, are required; also, two cedar boards 1 in. thick, 14 in. wide, and 13 ft. long, free from knots. The latter will be called the side-boards. They should both be of same quality, so that one will bend as easily as the other. Cedar is used throughout, except where the name of the wood is given.

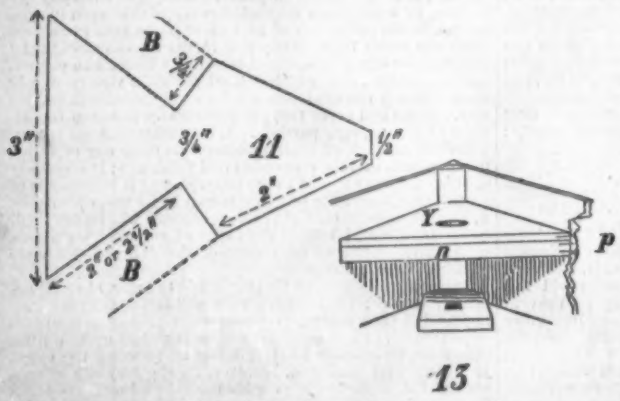


A piece is cut, shaped like Fig. 9, with the entire length 4 ft., the width 12 in., and the distance *d* from the end to the dotted line 4 in. We will name this the cross-board. A piece of oak is cut of similar shape, but making the entire length 20 in., width 13 in., and distance *d* 6 in. This is the stern-piece.

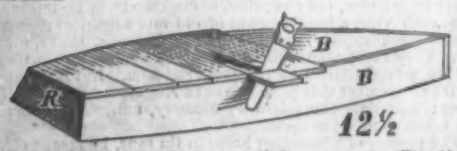
Both ends of each side-board are sawed off bevel, like the ends of the cross-board, and with same slant at both ends. The bevel at one end of the side-board should be the reverse of that at the other, making one edge 12 ft. 8 in. long, and the other 12 ft. The side-board has the appearance of Fig. 9 elongated. The tapering of the side-boards at the ends, which was necessary in the construction of the scow, is not required here. The necessary upward curve of the bottom is obtained by the bending of the side-boards, as described hereafter.



Set the side-boards (B B, Fig. 10) on edge parallel, with the longer edges uppermost, and at about the middle place the cross-board *t* between, also with its longer edge uppermost. Nail the side-boards B B lightly to the cross-board *t*. With the aid of ropes, draw two ends of the side-boards together; the other ends draw against the stern-piece (R, Fig. 10). In a piece of oak, about 16 in. long, cut grooves throughout its length, and make its cross section like Fig. 11. This "stem-piece," as it is called, is placed between the ends of the side-boards that were drawn together. After altering the shape of the stem-piece, if necessary, so that the ends of the side-boards (B B, Fig. 11) shall fit closely into the grooves, the side-boards are securely nailed to both stem-piece and stern-piece. The projecting upper end of the stem-piece is sawed off, and the boat inverted carefully.



The convex edges of the side-boards are planed down an inch or more at the middle (*c*, Fig. 12), so that the bottom (the boat is now bottom up) may be flat from *a* to *b*, making easy curves at *a* and *b*. This flattening of the bottom is not useless, the draft being thereby diminished, and the speed probably increased.

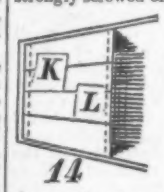


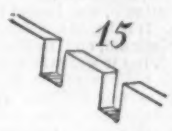
Bottom boards ¾ in. thick are nailed on crosswise (Fig. 12½), and the projecting ends sawed off. A long bottom board is put in, as before described for the scow (Fig. 8), and the cross-board, which was only temporary, is knocked out.

Fig. 13 represents the seat at the bow. The cross-piece *n* is secured by nails driven through the side-boards into its ends, as at P. In Fig. 14, which represents the seat at the stern, the cross-piece L is fastened in the same manner. There is a cleat at K. The seats in both bow and stern are about 3 in. below the edges of the side-boards, and the seat-boards are lengthwise.

We are now ready for the "upper streaks," as they are called. Two strips are cut 12 ft. 8 in. long, 2 in. wide, and 1 in. thick; two notches, each 1½ in. long, and nearly 2 in. deep, are cut in the upper edge of each side-board (Fig. 15). They are 3 in. apart, and the point midway between them is 5 ft. 1 in. from the stern, measuring on a straight line in the middle of the boat. All the longitudinal measurements hereafter given are upon this line.

The upper streaks are now nailed on the outside of the side-boards even with the upper edges of the latter, like the strips upon A A, Fig. 3. The joint made by the upper streaks at the bow is shown by Fig. 16, in which A is the stem-piece, B B are the side-boards, and C C are the upper streaks. The row-locks are now completed by a short strip (*y*, Fig. 17), strongly screwed on the inside, over the notches. Make thole-

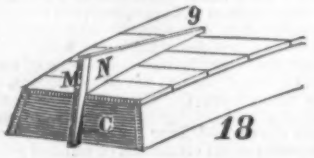




pins, of the shape shown by Fig. 6, and fit them into these mortices. It is often convenient to have another pair of row-locks about 2 ft. nearer the bow, that when a person sits in the

stern, the rower may shift forward to better distribute the weight, for a boat rows hard when the stern is weighted down.

Make two cleats for the rower's seat, with their aft ends 6 ft. from the stern, and their upper edges 7¼ in. below the edges of the side-boards. Saw off a seat-board 3 ft. 10 in. long.



Invert the boat and fit a piece of inch-board (N, Fig. 18) upon its edge, at the stern, upon and perpendicular to the bottom. It is fastened at *g* by a screw, between *g* and M, by nails driven into it through the bottom from the inside of the boat; and by the strip M, of the same thickness, nailed on the end of N, and crossing the stern-piece vertically, to which it is screwed.

A ¾ in. hole is bored through the stem-piece at *l*, Fig. 19, through which the painter, 10 ft. long, is tied. An iron strap, shaped like the double line in the same figure, is screwed to the cutwater.

The proper length for oars is about 7 ft.

The boat is now caulked, unless already rendered water-tight by one of the equivalent methods described for the scow in our first article. Nail-heads are covered with putty, two coats of paint are applied, and the skiff is completed.

In our next we will describe the method of making a centre-board sail-boat.

THE MODERN YACHT.

THE following are particulars of a new schooner-yacht lately built for Mr. Peabody Russell, by Messrs. C. & R. Poillon, Brooklyn. She has been built with great care and without hurry. Her keel is in two tiers, she being a keel-yacht, with two pieces in the lower and three in the upper tier, and extends two feet below the rabbit. It is 86 feet long, and with the rake of stern and stern post and the over-hanging stern of 8 feet she is 103 feet over all on deck. Her beam is 18 feet 7 inches, and she has 9 feet depth of hold. Her frame is of oak, hackmatack, and locust, the latter running up and forming stanchions for the bulwarks, fifty on each side. Her outside planking is 2½ inches on the bottom and 3-inch walls. The inside ceiling is 3 inches from the bilge up, and 2 inches below. The deck is 2½ inches square, and is what is called "blind nailed," that is, fastened at the sides, so that the nail-heads or plugs can be seen. This is the first yacht fastened in this way, and makes an extremely neat-looking deck. The planks are spiked diagonally through their sides, below the seams to the beams and carlings, and between the beams and carlings, bolted transversely to each other. She has two stern posts, with recess between them for a screw propeller, with bed-piece for the shaft and hole through the forward post, but all this is planked up at present, as her first essay will be as a sailing yacht, and there is barely to be seen the swell or bulge on each side of the stern-post in the wake of the shaft-hole. Into her keel is run 3½ tons of lead, and her inside ballast will be of the same material, run to fit her frames. Her deck combings and mast-partners are mahogany, making a complete course of that wood, fore and aft. Her deck is flush. Her cabin will be roughly fitted for this season's cruising, as her owner prefers to have her joiner-work done in Europe, where she will go at the close of the season, and when there her bulwarks will be panelled in the English style. She will there also receive her machinery, and be transformed into a steam-yacht. She is to be commanded by Captain Belmont, who took over to Europe the yacht Foustine, for the same owner. Her spars are taunt, and she will spread a large area of canvas. Her mainmast is 70 feet and foremast 69 feet long, both 15 inches in diameter at the partners; both topmasts are 30 feet long. Her bowsprit is 25 feet outward, and she has no jib-boom, her jib-stay going down through a hole in the bowsprit about two-thirds of its length out, and setting up to a long rod secured with a fork to the stem, where it is bolted through and through. This stem bolt is the sole fastening she has for the bowsprit, there being a shoulder worked on it just outside of the stem, with eyes above and below, and the inner bobstay comes to the upper eye, with the outer one from the boom end to the lower one. This makes a very neat fitting, though the wisdom of trusting so much to one rod is questionable. She will have a forestay, however, coming down to the knightheads, and this will take the strain off the masts. Her main boom is 54 feet and gaff 26. The foresail will be a lug. The new yacht is not yet named, but she will be certainly entered for the centennial regattas, and, as she is extremely sharp, with a nice clean run, she may be looked for at the finish somewhere among the leaders.

EXTINGUISHING FIRES ON SHIPBOARD.

A METHOD of extinguishing fires on ships has been lately submitted to the Russian Admiralty. Two receptacles hermetically sealed, and containing anhydrous bicarbonate of soda, are to be placed in the forecastle of the vessel, with two retorts containing sulphuric acid connected with them by a siphon, but closed by means of stopcocks. In case a fire breaks out, the cocks are to be opened, when the mixture of the two substances will generate carbonic acid, to be led through pipes provided for the purpose into the hold, and thus to extinguish the fire. The commission charged with examining into this method reported against it on account of the danger to the crew in case of breakage or leakage of the tubes, and also because, carbonic acid being heavier than air, it would be difficult to free the vessel from it. The *Rivista Maritima* considers, however, that this plan might be adopted with advantage in the powder magazine and in sections of the vessel which are isolated from the rest; besides this, substances are stored on board vessels much more dangerous than carbonic acid, which might be the means of preventing an explosion and the loss of everything.

RIFLING HEAVY GUNS.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

PROFESSOR E. L. ZALINSKI, U.S.A., read a paper, illustrated by numerous diagrams and models, on a new system for rifling heavy guns, devised by Mr. S. P. Ruggles, well-known as the inventor of many ingenious mechanical devices.

Mr. Ruggles' plan of rifling cannon, and projectiles to be used therewith, was shown by a model, on a scale of 1′ to 1′. the bore being 12′ long and .25′ in diameter. It contains sixteen grooves of a serrated shape. The grooves used in United States cannon are rectangular, similar to those of square-threaded screws. Mr. Ruggles claims that this is unnecessary, as only *one* side of the groove is subjected to any strain or bearing in firing; that, whilst in the screw, it is necessary to have bearings on *both* sides in order to move it forward and *back*, in a gun the rotary motion is required only whilst the projectile is moving *forward* out of it. In consequence of this, twice the number of serrated grooves, each having the same effective bearing surface as the rectangular groove, can be cut in the bore, doubling thereby the effective bearing surface, without weakening the gun; the depth of these can be reduced by one half if the former amount of bearing surface was considered sufficient, and weaken the gun less than by the service method.

The projectile has an expansive sabot of soft metal to be forced into the grooves by the powder-gas, and thus give the required rotary motion. From this kind of groove the sabot is enabled to expand, fitting closely to the surface of the bore at every point, utilizing the entire force of the powder-gas and preventing its escape (which is not the case with the service groove). The results attained with a given weight of powder will be more uniform than when a large amount of gas is permitted to escape, as in the service groove. This model exhibited the difference of windage of the two systems of grooves.

Around the front of the projectile, near the junction of the cylindrical and conical portions, is a soft metal hoop, which is to be expanded by the powder-gas that must pass the base sabot at the first moment of the explosion; this will cause it to expand sufficiently to *centre* the front end of the projectile, although it may not have filled the grooves. The band is put on loosely, so that it may turn. The object of this will be seen hereafter.

A great variety of opinion exists as to the rate and kind of twist which should be given to rifling. There are two kinds of twist used—"uniform" and "varying."

The uniform twist is one which imparts the required rotary velocity upon starting the projectile. The increasing variable twist is one which causes the projectile to move straight forward at first, and then gradually acquire its ultimate rotary velocity at the muzzle.

Mr. Ruggles proposes to use an increasing twist, and considers that one based upon the law of gravitation will give the best results. By an ingenious device he has made the twist on this cylinder an exact copy of the law, as to progressive increments of pitch, giving the projectile one revolution in travelling the first 48′ of its flight.

By his device of a loose collar around the front of the projectile, Mr. Ruggles meets one of the objections to the use of the variable twist. If this were held fast to the projectile, there would be a tendency for the front and rear of the projectile to have different rotary velocities. One or the other would have to "slip," and additional friction and resistance would result therefrom.

PROTECTION OF WAR SHIPS FROM TORPEDOES.

AN experiment is soon to be made on the British man-of-war Thunderer to test the efficacy of a network of iron wire with which it is proposed to encircle the iron-clad war-vessel of the future for purposes of protection. The netting is to be supported by booms at a distance of twenty-two feet from the sides, and kept rigid to below the depth of the keel by heavy weights. The danger to be guarded against is the fish-torpedo, one species of which can be unerringly propelled under water for a mile, and will then sink a ship if it strikes her. It seems to be certain that unless some good defence against the approach of torpedoes can be invented, the construction of war ships will have to be greatly modified.

LESSONS IN MECHANICAL DRAWING.

By Prof. MACCORD, Stevens Institute.

(Continued from page 381.)

No. XIII.

FROM the description given of the T square in the preceding lesson, it will at once strike the reader that much of the work of constructing the exercises heretofore presented would have been much facilitated by it; as the horizontal and vertical lines would naturally occur to any one as the most convenient for reference, even in drawing a mere geometrical diagram in which the absolute directions of the lines are of no consequence. In the use of the triangles alone, no doubt the student has felt the inconvenience of being obliged to adjust them with reference to some line already drawn, every time he wished to draw a line parallel or perpendicular to it, or at an angle of 45°, 60°, or 30°, with it. With this new implement in his hands, however, this trouble is saved: it is only necessary to apply the stock to the board, and the blade assumes at once the proper direction. But being thus purely a mechanical contrivance, it must be correctly made in order to be reliable: the stock, it need hardly be pointed out, must be perfectly straight, in order properly to apply itself to the end of the board, under all circumstances. It is perfectly obvious that it would not do to have the edge of the stock convex, since then it would roll, or rock, upon the board, and the blade might thus be made to swing through a perceptible angle without sliding along at all. But it is not so self-evident that a *concavity* of the edge of the stock would give rise to difficulties of that sort—nor indeed down until the lower half of the stock projects below the edge of the board, as at B, when, as shown, the curvature of the stock will throw the blade out of parallelism.

It is, then, essential that both blade and stock be straight, and rigidly secured together; and also that the blade be heavy enough to prevent springing sideways. This stiffness is to be secured by increasing the breadth, not the thickness: flexibility, to some extent at least, in the other direction, is no disadvantage, but it should not be so great as to prevent the raising of the square perpendicularly off the board by the stock alone—the rubber blades referred to are very faulty in this respect, unless exceedingly short, as they bend nearly double by their own weight, so that to avoid danger of breaking it is necessary to use both hands, supporting the end of the blade with the right: this is very inconvenient, and involves great waste of time. For, although it may seem superfluous, it may yet be well to state that, in order to use the square to advantage, it should be grasped by the stock with the left hand, applied to the left end of the board in drawing horizontal (that is, longitudinal) lines, and to the lower side, or the one nearest the operator, in drawing transverse or vertical lines: and that the pencil or pen is to be applied on the upper or the left-hand edge, as the case may be, in drawing the lines.

Thus handled, the T square enables us to do work with great facility and dispatch; there is no time lost in adjusting its blade as to direction, and thus having only to set the edge at a given point, with the left hand, this facility is still farther increased by the right hand being free to use the other instruments. There is also an evident advantage in point of accuracy, supposing the board and square to be what they should be, since every setting of the triangle involves at least a possibility of error, and time is lost in consequence of the care needed to guard against such error.

But the student who has, by the construction of the exercises already given, acquired dexterity in manipulating the triangles by themselves, will find that the acquirement is worth all the trouble it may have cost him. And he will find it so much the easier to use them in connection with the T square; the latter furnishing a base, to which one or the other of them may be applied, thus determining at once the directions of the remaining sides, gives the means, to one who is master of the resources furnished by the set-squares, of abbreviating many of the operations of mechanical drawing to an extent which is astonishing in view of the simplicity of the means.

Now, to proceed with our practice: we give in Figs. 124 and 125 two exercises involving the use of circular arcs only, the points to be specially looked after being the intersections and the shadow-lines. They are founded respectively on the trefoil and the quatrefoil, figures much used in Gothic architecture; but no pretence is made to their being properly proportioned for any particular purpose, the idea being to make them exercises only, in reference to the points above mentioned.

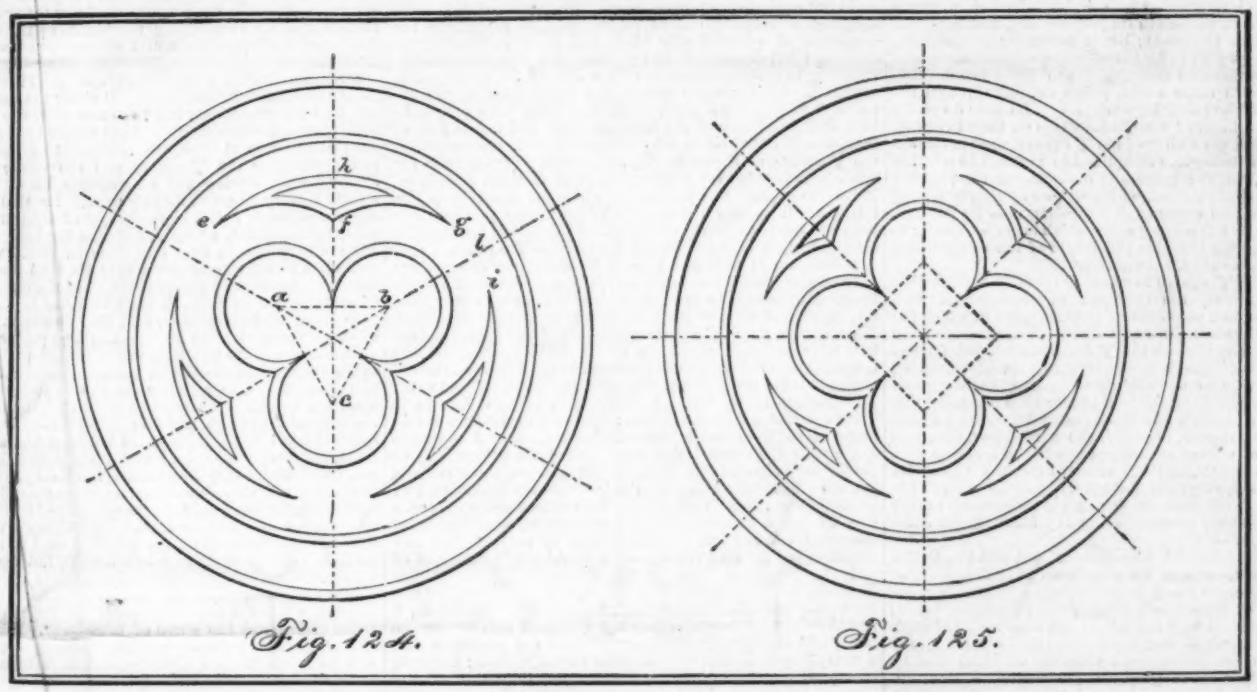


Fig. 124. Fig. 125.

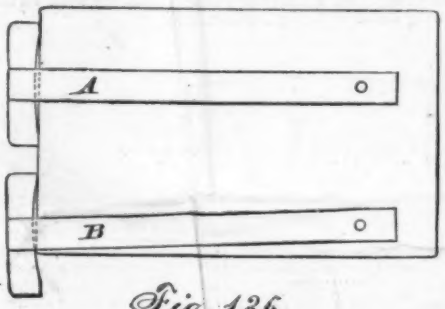


Fig. 126.

The trefoil, Fig. 124, is constructed by first drawing the equilateral triangle, *a b c*, and then, with a radius equal to half its side, drawing three arcs, whose centres are the vertices of the triangle, and terminating in its sides, the adjacent ones being thus tangent to each other at their extremities. With the same centres, three other arcs are drawn, with a greater radius, thus surrounding the trefoil with a band or moulding; these arcs will not be tangent, but intersect each other, and the points of intersection will be on the centre-lines drawn through the vertices of the triangle. The arc *e f* is struck from the centre *a*, the arc *f g* from the centre *b*, and *e h g* from the centre of the triangle itself; these three arcs form by their intersections a sort of curvilinear triangle, *g f e*, within which is drawn a smaller one, the latter thus appearing like the trefoil to be surrounded by a moulding. The other two similar figures are formed by a like proceeding from the other vertices of the triangle, and the whole finally surrounded by a double band or moulding.

It is proper to point out, although we hope that it is not altogether necessary, that it is better to draw one of the larger circles first and divide it at once with the compasses, than to construct the triangle and afterward prolong the bisecting-lines of its angles. And in order to secure perfect symmetry, especially in regard to the spaces between the sharply-pointed terminations of the three curvilinear triangles, the following process may be used to advantage: the arc *e h g*, whose absolute length is arbitrary, may in pencil be drawn a little beyond where we know it is to terminate, and with the same radius let a point, as *l*, be marked on the line which bisects either angle of the triangle; then let equal distances, *l g*, *l i*, be set off from this point *l*, thus determining the radius *b g* of the arcs *g f*, *e f*, etc.

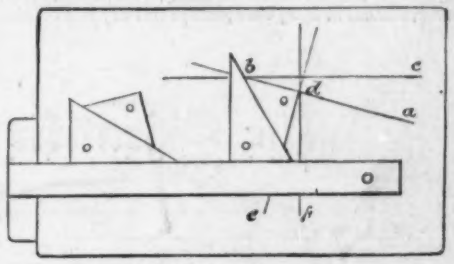


Fig. 127.

The quatrefoil in Fig. 125 is constructed in a manner precisely analogous, the fundamental figure being a square, each angle in succession being made the centre of an arc whose radius is half the side, thus forming the four-lobed outline of the central opening, which is afterward surrounded by a moulding, four curvilinear triangles and the external circular frame-work, the various steps requiring no further explanation.

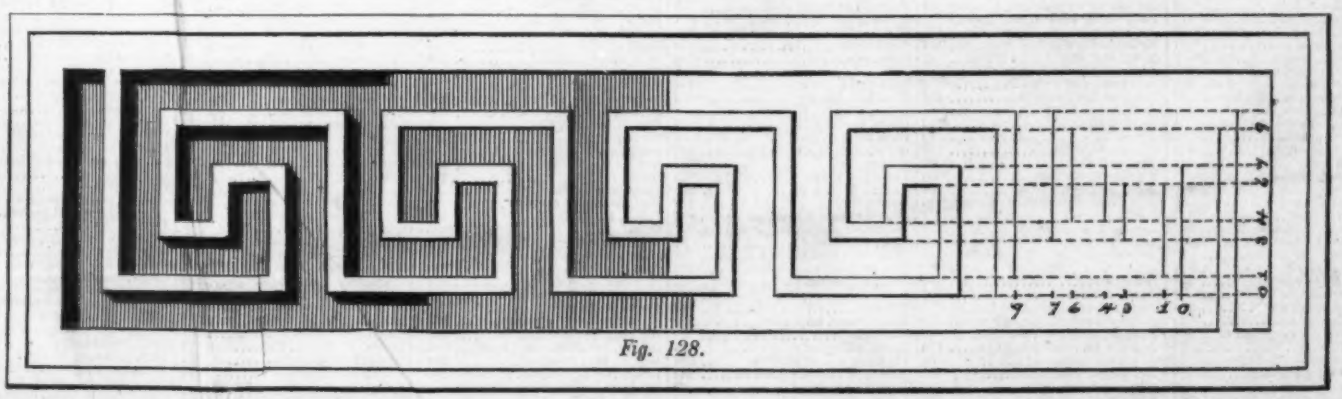


Fig. 128.

will it, in every position. But we wish the reader to understand that he should be as particular in testing the stock of his T square as he is in testing its blade, which he knows *must* be a perfect straight-edge; and we introduce Fig. 126 to show the reason of this necessity.

The concavity of the stock is greatly exaggerated; but a very slight hollow in it is sufficient to produce very annoying results: so long as both ends are supported by the drawing-board, as in the position shown at A, the lines drawn by it will be parallel; but in order to do work near the lower edge of the sheet, it is often necessary to slide the square

These exercises, though not more simple, are far less difficult than those given in Figs. 119 and 120. But the difficulties, such as they are, are of a very different kind. We have here no tangencies (except those of the arcs bounding the trefoil and the quatrefoil themselves), but we have a number of intersections of arcs, some of them very acute, and, by reason of their peculiar arrangement, appealing in the most pointed manner to the sense of symmetry, if we may use the expression.

In order to make the drawing satisfactory to the eye, then, it is necessary to pay scrupulous attention to the sharpness

and accuracy of the intersections. Any of the faults pointed out in Fig. 32 will produce disastrous results if they find their way into these sharply-curved, crescent-like figures. And the skill of the operator is the more severely taxed by reason of the fact that the shadow-lines are to be introduced.

Having explained in a previous lesson the manner in which to determine the points at which the shadow-line is to begin and end, it would be superfluous to go into that question again in detail here; it suffices to say, in reference to the possible doubt as to which lines do cast the shadows, that all the narrow mouldings are supposed to be raised above the surfaces upon which they are placed. The novice, we take it, will probably be contented with giving a smooth, properly tapered shadow-line to each in its proper place, making all of them of the same thickness; but if he wishes to make his drawing more expressive of what may properly be imagined—that is to say, of the fact that the trefoil and the quatrefoil are *openings*—or in other words, pierce entirely through the wall upon which the mouldings are placed, he may do so by doubling the thickness of the shadow-lines on their interiors.

And he will find the utility of his T square, used in connection with the 45° triangle, exemplified in perhaps as striking a way as any, in the process of determining the limiting points of these shadow-lines, which is done by simply sliding the triangle along its upper edge, supposing it to be horizontal, till that one of the sloping sides which is perpendicular to the light-ray passes through the centre of the circle which proposes to cast the shadow in question.

This use of the T square as a sort of portable base, for the purpose of adjusting the triangles as to direction with rapidity, is, however, not confined to those cases in which the sloping sides of the latter are to be used. Some persons seem to have an idea that because the T square is capable of determining two sets of lines, it must always be used for drawing both of these sets, and accordingly will move the instrument from the end to the side of the board every time a vertical line is to be drawn, no matter how short it may be. And we have heard solemn arguments, of which the burden was, that this was necessary to ensure accuracy, since if the verticals were drawn by the triangle, and the triangle did not agree with the drawing-board, why, the lines would not be true. It is not worth while to dispute either this assertion, or the other equally pertinent one, that when the sky falls we can catch larks without traps.

The simple fact of which we must not lose sight is, that a right angle measures 90°, whether it be in the triangle or the drawing-board; and if they do not "agree," so much the worse for one or both the implements. They *must* agree; and the draughtsman who appeals to the results of his experience to sustain this line of argument, should patch up the quarrel between his instruments, when he will find that he can draw true lines with a good triangle as well as false inferences from a bad one.

The reason for preferring to use the triangle, in drawing short offset lines perpendicular to the T square, whether the latter happens to be at the time applied to the end or the side of the drawing-board, is that it saves time to do so. The triangle can be put in position much more quickly than the larger square can be raised and turned round. And as will be seen when we come to it, in the drawing of machinery especially, matters so shape themselves that we have a great many short verticals to draw, which will render this saving of time, which for one or two lines would be scarcely appreciable, an item of very considerable consequence. And the saving is the greater, because in using the square in this way it is not necessary to keep the hand upon the stock. Once applied fairly to the board, it is kept in position by pressing on the blade with the thumb and a finger of the left hand, the other fingers being free to assist in the manipulation of the triangle, which, bearing on the upper edge of the blade, is readily pushed up along with the square when it is moved up, and as readily brought into adjustment again when it is moved down, in case new horizontals are to be drawn; besides all which, the dividers, scale, or compasses may conveniently be laid down upon the blade, and moved with it as it slides. They are thus always at hand when wanted, and this at least could not be done if the square were to be changed from side to end and back again every few moments. We insist yet that accuracy and neatness are more important than rapidity in the execution of work of any kind, and more particularly of drawing; but despatch is an important qualification notwithstanding, and all reasonable means should be employed to attain it. Among these means, the "fluent use of the triangles," to which so much space and time have purposely been devoted, is one of the most efficient; and this is just as true, whether they be used by themselves or in company with the T square, as shown in Fig. 127, which represents the 60° triangle in position for drawing the short verticals spoken of. It may be worth while to add that when the short leg of this triangle will answer the purpose of drawing the lines, it is better to use it as shown at the left of the figure, because this selection gives a longer bearing against the T square.

This figure is intended also to show another thing which may be done with the triangles: it was possible, of course, by the instruments themselves, to divide the circle into four, six, eight, and twelve parts, as has been already described. Now, applying the T square to the end of the board, and the 60° triangle to it, as shown at the right in Fig. 127, its hypothenuse (or longest side) makes of course an angle of 60° with the horizontal. Now, applying the 45° triangle to this hypothenuse in its turn, as shown, it is evident that we in effect subtract 45° from 60°—that is to say, that *a b* makes an angle of 15° with the horizontal line *b c*, and *e d* the same angle with the vertical line *d f*. And if the 60° triangle be placed on its longer side, as at the left, the two short sides of the other one make also angles of 15° with the horizontal and vertical lines respectively, but the inclinations are in the opposite directions as compared with the others, as if *b a* sloped downward to the left from *b* instead of to the right, and similarly with regard to *e d*, which would fall to the right of *d f*. By the use, then, of the triangles, separately and together, in connection with the T square, we can lay off mechanically angles of 15°, 30°, 45°, 60°, and 75°, with the horizontal or vertical line, dividing the quadrant into six, or the circle into twenty-four equal parts. It is not pretended that this is always the best way to make such divisions; but still, as the main difficulty lies in drawing the diameters exactly through the centre of the circle, it will effect the object with a sufficient degree of precision for very many practical purposes, and familiarity with all these capabilities of these little general utility contrivances will go a great way in saving labor and time, as we shall see more clearly in the construction of mechanical details.

We give in Fig. 128 an exercise in simple line work, which will in the execution illustrate the advantage of using, as we have suggested above, the triangle for drawing the short vertical lines, which constitute a very large portion of it. The figure represents a panel ornamented with fretwork in the Greek style, the panel being sunken and the fretwork raised, in order to give the full effect of which a portion is shaded, heavy sunlight shadows being also introduced on the extreme left. On the right a portion is left unfinished in order to illustrate the construction, which is extremely simple.

The horizontal dotted lines indicate the construction lines, which are first of all to be drawn lightly in pencil from end to end. The distances between these lines are indicated by the figures in the vertical row at the right, which are the numbers of divisions on any scale of equal parts. Thus in the figure: from 0 to 1 is one eighth of an inch; from 0 to 3, three eighths; to 4, one half; to 6, three quarters, and so on. In other words, we set off from the starting point, or zero, alternately an eighth of an inch and a quarter of an inch, or any other spaces in the proportion of one to two. The longitudinal spacing is precisely the same, as indicated by the figures on the lowest horizontal construction line of the fretwork pattern.

Thus, drawing all the horizontals first, and then marking off these points, as 1, 3, 4, 6, 7, etc., all along the line, and begining with the triangle at the left-hand side, the verticals are rapidly drawn of precisely the right length in pencil, and may then be inked in at once, the horizontal outlining with the pen next, using the T square, and the whole is ready for shading after erasing the construction lines. These latter should be very fine and lightly drawn, for this is one of the cases in which it would be the height of absurdity to attempt even, by repetition of measurements for each member and parts of members, to stop *every* line in pencil where it is to end in ink; all the verticals may be thus treated, but the horizontals should be drawn through at the outset, at least as far as the fretwork extends, but no farther beyond that limit than necessary to make sure that they do not stop short of it, of which the eye should be able to judge pretty accurately.

The line shading will be found excellent practice, not only in training the hands in the manipulation of the T square and triangle, but in training the eye to judge accurately of spacing; for this is done by merely moving the triangle along the edge of the square, and no spacing dividers will be of any service in getting the distances between the shading lines right, for even if they were accurately pricked off on the paper, the difficulty would be to draw the lines precisely through the points, and the eye which can ensure that can with equal ease and certainty determine the equality of such small spaces without any points to look at. That is, until the eye tires; different individuals are differently endowed by nature in this respect; practice will do much for all, but there are some whom no amount of practice will enable to overcome an inherent uncertainty in the execution of this kind of work, while others can rule the whole surface of a large plan with the precision and almost the speed of machinery. Still, if practice will not in all cases make perfect, according to the proverb, it will do much in that direction, and it is by no means the worst employment for spare moments when they are too few to be advantageously used in other and more important work. By this, however, we do not wish the reader to be misled in regard to one point, which is, that it is not well to shade a surface, in a finished drawing, piecemeal. The eye and hand having once got the *rhythm* of a certain tone in shading, it is best to keep on continuously until the whole of that surface is shaded, if it be possible to do so; there is danger of losing the precise spacing, thickness of line, or in light work (where the use of thinner ink is admissible) the tint, or depth of tone of the lines. And if it be not possible, the precaution should be taken of practising a little on a loose piece of paper, in order to avoid any such discrepancy, before resuming work on the drawing itself.

(To be continued.)

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*The * indicates that the article is illustrated by engravings.*

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